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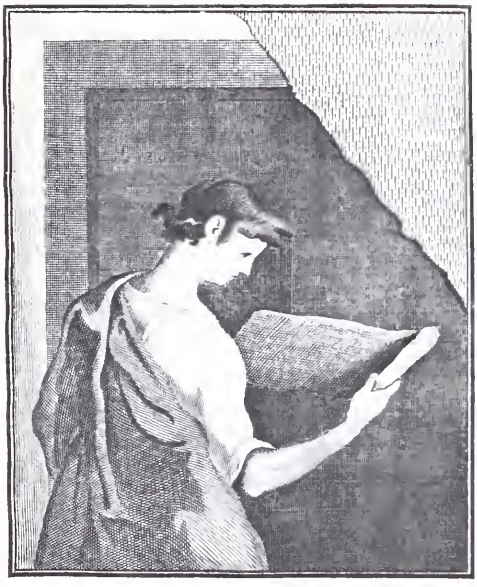

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TRANSACTIONS

OF THE

INSTITUTE OF BRITISH ARCHITECTS

OF

LONDON.

SESSIONS 1835—36.

VOL. I. PART I.

USUI CIVIUM, DECORI URBIUM.

LONDON 1836.

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TRANSACTIONS

OF

THE INSTITUTE OF BRITISH ARCHITECTS.

1835—36.

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* In addition to this List of Writers on the Polychromy of Ancient Art, the names of the following Authors are given, who have also more or less treated on the subject in their works:—

Requeno: Saggi sal Ristabilimento dell' antica arte de' Greci e de' Romani pittori, Venice, 1784.

Winckelmann: Histoire de l'Art chez les Anciens, 2 vol. 4to. Paris, 1802.

Boettiger: Amalthea, oder Museum der Kunstmythologie und bildlichen Alterthumskunde, 3 vol. 8vo. Leipzig, 1825.

——— Ideen zur Archæologie der Malerei, 8vo. Dresden, 1811.

Dodwell: A Classical and Topographical Tour through Greece, 2 vol. 4to. London, 1819.

Davy, H.: Some Experiments and Observations on the Colors used in Paintings by the Antients, Philos. Trans. 1815, p. 97—124.

Inghirami: Galleria Omerica—Poligrafia Fiesolana, 2 vol. 8vo. 1831.

——— Monumenti Etruschi, 4to. 1819.

Gell and Gundy: Pompeiana, 2 vol. 8vo. London, 1820. Second Series, 2 vol. 8vo. London, 1832.

C. R. Cockerell: On the Ægina Marbles, in the Journal of Science and the Arts, vol. VI. art. xv.

Wagner: Bericht über die Aeginetischen Bildwerke, 12mo. Tubing, 1817.

Millingen: On Vases discovered at Volci, and other places in Etruria, Transactions of Royal Society of Literature, vol. II. Supplement, p. 1.

Pitture d'Ercolano:

Museo Borbonico:

Stieglitz: Archæologie der Baukunst.

Müller, K. O.: Die Etrusker, 8vo. Breslau, 1826.

——— ——— Handbuch der Archæologie der Kunst, 8vo. Breslau, 1828.

——— ——— De Phidiæ Vitâ, 4to.

Donaldson: Temple of Apollo Epicurius, Stuart's Athens, vol. V. p. 17, folio, London, 1830.

Hermann: De veterum Græcorum pictura parietum conjecturæ, etc. Leipsich, 1834.

Wiegmann, A. F. A.: Die Malerei der Alten, in ihrer Anwendung und Technik, nebst vorrede von K. O. Müller, 12mo. Hannover, 1836.

The following are some of the ERRATA, which the Reader is requested to correct.

Page vii, 7th line, for *Honorary Members* read *Honorary Fellows.*

xxiii, 8th line from bottom, for *we should hope it may admit* read *we should hope may admit.*

xxiv, 22nd line, for *Hon^ble. Sec^y.* read *Hon^y. Sec^y.*

xxvii, 14th and 15th lines from the bottom, for *spoilation* and *spoilations* read *spoliation* and *spoliations.*

—— 6th line from bottom, for *drilling* read *walling.*

xxxi, 2nd line from bottom, for *J. B. Papworth, Fellow*, read *J. B. Papworth, V.P.*

75, note ‡, for De l'Architecture Polychrôme *du Grecs* read *des Grecs.*

INSTITUTE OF BRITISH ARCHITECTS.

1836.

LIST OF COUNCIL.

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Vice-Presidents.

CHARLES BARRY. J. B. PAPWORTH.
P. F. ROBINSON.

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T. L. DONALDSON. CHAS. FOWLER.

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H. E. KENDALL. HENRY RHODES.
GEO. MOORE. GEO. L. TAYLOR.
ROBERT WALLACE.

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SIR WALTER ROCKCLIFF FARQUHAR, Bart., St. James's Street.

Honorary Solicitor.

WILLIAM L. DONALDSON, 7, Hart Street, Bloomsbury Square.

FELLOWS.

GEO. TOWNSEND ANDREWS, York.
SAMUEL ANGELL, 2, Southampton Street, Holborn.
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CHARLES BARRY, 27, Foley Place. (Trustee.)
G. BASEVI, Jun., 17, Saville Street, Bond Street.
SAMUEL BEACHCROFT, Sloane Terrace, Chelsea.
THOMAS BELLAMY, Chambers, Albany, Piccadilly.
EDWARD BLORE, 62, Welbeck Street.
W. J. BOOTH, 32, Red Lion Square.

W. M'Intosh Brookes, 6, Adam Street, Adelphi.
William Burn, 131, George Street, Edinburgh.
Decimus Burton, 6, Spring Gardens.
William Deane Butler, 73, Stephen's Green Square, Dublin.
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Thomas Chawner, 82, Guildford Street.
Thomas Cundy, Chester Square, Pimlico.
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Charles Fowler, 1, Gordon Square.
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John B. Gardiner, Bank Chambers, Lothbury.
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H. E. Goodridge, Bath.
George Gutch, Bridge House, Paddington.
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Wm. Hosking, 23, Woburn Square.
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William Southcotte Inman, 3, Eaton Square.
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Henry Lant Keys, 6, Regent Street.
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David Mocatta, 63, Guildford Street, Russell Square.
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J. B. Rebecca, Gloucester Hotel, Piccadilly.
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Henry Rhodes, 26, Margaret Street, Cavendish Square.
P. F. Robinson, 29, Brook Street, Grosvenor Square.
Anthony Salvin, Somerset Street, Portman Square.
J. J. Scoles, 11, Argyle Place.

Henry Hake Seward, 10, South Audley Street. (Trustee.)
John Shaw, Christ's Hospital.
George F. Smith, Frederick's Place, Old Jewry.
George L. Taylor, Somerset Place, Somerset House.
John Henry Taylor, 22, Parliament Street.
James Thomson, 35, Foley Place.
Robert Wallace, Parliament Street.

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Sir John Soane, R.A., Lincoln's Inn Fields.
Sir Jeffry Wyatville, R.A., 50, Lower Brook Street.
Sir Robert Smirke, R.A., 5, Stratford Place.
Charles R. Cockerell, R.A., 87, Eaton Square.
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Peter Legh, Esq., Norbury Booth's Hall, Knutsford, Cheshire.
Joseph Neeld, Esq., m.p., Grosvenor Square.
James Morrison, Esq., m.p., Upper Harley Street.
Charles Morrison, Esq., do. do.
William Mountford Nurse, Esq., 7, Langham Place.
Thomas Lewis, Esq., Walker's Hotel, Dean Street, Soho Square.
Charles Henry Christian Lang, m.d., Sheffield House, Kensington.

HONORARY MEMBERS.

John Britton, Esq., Burton Street, Burton Crescent.
Dr. Michael Faraday, Royal Institution, Albemarle Street.
His Majesty the King of Oude.
His Highness the Rajah of Tanjore.
The Rev. William Whewell, m.a., Trinity College, Cambridge.
The Rev. R. Willis, m.a., Downing College, Cambridge.
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A. J. M. Guenepin.
Achille Le Clere.
Francois Debret.
L. H. Le Bas.
J. N. Huyot.
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I. Hittorff, Architect, Paris.

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Chevalier Stefano Gasse, Architect, Naples.
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Karl Friedrick Schinkel, Architect, Berlin.
Chevalier Leo von Klenze, Architect, Munich.
Friedrick Gartner, Architect, Munich.
G. Hetsch, Architect, Copenhagen.
L. Reijers, the Hague, City Architect.
— Suys, Brussells, Architect to H. M. the King of Belgium.
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Signor Ferdinando Albertolli, Member and Professor of the I. and R. Academy of Fine Arts at Milan.
Signor G. Borsato, Member and Professor of the I. and R. Academy of Fine Arts at Venice.
Monsieur Beuth, Berlin, Privy Counsellor of H. M. the King of Prussia.
Don Sebastiano Ittar, Architect, Catania, Sicily.
Ithieb Town, Architect, New York, United States, America.
Frederic Catherwood, Architect, America.
Professor Sprenger, Architect, Vienna.
Alexander Bruloff, Architect, Petersburg.

ASSOCIATES.

Thomas Allom, 51, High Street, Camden Town.
Henry Appleyard, Montague Street, Russell Square.
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Alfred Burton, Spring Gardens.
Walter Crosby, Plowden Buildings, Temple.
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John Douglas Hopkins, 7, Cleveland Street, Fitzroy Square.
Sampson Kempthorne, Carlton Chambers, Regent Street.
Henry Edward Kendall, Jun., 23, Hunter Street, Brunswick Square.
Charles Evans Lang, 1, Denmark Terrace, Camberwell.
Charles Marriott, 89, Fleet Street.
Frederick William Mountague, Guildhall.
Samuel Sharp, York.
William Smith, Cole Hill Lodge, Fulham.
W. Crawford Stow, 18, Chester Place, Kennington.
Samuel Sanders Teulon, 24, Upper Stamford Street.
Frederick Thatcher, 3, Southampton Buildings, Chancery Lane.
Francis Wright Tuach, Bermondsey High Street.

ADDRESS,

ETC.

Few of the arts and sciences are now left without a body associated for their promotion and cultivation, and for the purpose of fostering and stimulating the talents of individuals in the advancement of those peculiar studies to which each is devoted. Architecture, however, which embraces the whole circle of the sciences, and, in its higher branches, is of paramount importance to a civilized nation, had until lately been destitute in this country of such an establishment.

An Association for such a purpose must be obviously advantageous to the country at large, from its responsibility to public opinion for the direction and maintenance of the national character for taste, and from its affording a body to whom Individuals may have recourse for its opinion upon professional matters. But no less beneficial must it be to the general body of the Profession, from a determination to uphold, by their united exertions, the character and respectability of its Professors.

With a view to the promotion of such important objects, the founders of The Institute of British Architects have united. A few of the advantages they contemplate, and the utility that may be expected to result from their association, will therefore be here stated briefly, but it is hoped sufficiently to ensure the patronage and co-operation of the enlightened lovers of the art among the ranks of the Nobility and Gentry of these Realms.

The Members of the Institute are either Professional or Honorary. The former being divided into two classes, as Fellows and Associates. The Honorary Fellows consist of Noblemen and Gentlemen, donors to the amount of no less than twenty-five guineas in one sum; and Foreign Architects, or men distinguished for their scientific attainments, whether in this or any other country, are admitted as Honorary Members, without contribution.

The formation of a Library of printed works of every species connected with Architecture, is, of course, of primary importance. To this, it is hoped, may be added manuscripts of a similar description, to be deposited for the

inspection of all the members, and drawings illustrative practically and theoretically of the art, in its widest application.

Another object of the Society will be the publication of such communications as may be curious and interesting to the Public and to the Profession.

The Institute are now forming a Museum of antiquities, models, casts, specimens of materials used in building, and of all such other objects as may tend to the illustration of the Arts and Sciences in their application to design and construction; and have it in contemplation to provide means for performing experiments on the nature and property of materials, as respects their useful employment in construction.

It is presumed that, independently of the manifest advantages which must result from the periodical meetings of the Members of such a Society, great and lasting benefits may be justly expected from the spirit of laudable rivalry and enquiry induced and diffused amongst them; and from the mutual good understanding between its Members, promoted by their frequent meetings; to which may be added, the knowledge circulated by their intercourse, and the discussions consequent on a correspondence proposed throughout Europe, relative to any great works in progress, or already executed, in different countries.

With such views, and with the object of gaining at the hands of the public a reliance on those professors, who are *bonâ fide* Architects, one of the principal features will be the maintenance of a high standard of professional character and honorable practice among the Members.

Without aid beyond the circle of its professional Members, it will at first perhaps be difficult to carry such a Society into full effect. The founders in this respect cannot but rely on the munificence, which distinguishes so many Noblemen and Gentlemen of this country, in their patronage of the fine arts, for assistance to the Institute, in whose success they are necessarily interested. For such extensive views, the funds will of course depend on the number of its Members: of these it is at present impossible to form an adequate estimate, but on them must depend the extent of their application. It may not perhaps be assuming too much to suppose that, as in the case of other Societies, certainly not more important to the community, the Government will not only afford to the Institute a place for holding its meetings and depositing the collection which it may acquire, but will also readily acquiesce in the application for a Charter, by which it may be incorporated. Beyond the ordinary expenses of the Institute are those attendant on the occasional periodical publication of communications; the payment

occasionally of draftsmen, in cases of extraordinary or interesting buildings, a memorial of which should be preserved; the formation of the library and perhaps the distribution of prizes for works, which have been published by the Members; for the encouragement of particular branches of architecture, by essays or designs, theoretical and practical, and for the suggestions of improvements in building, worthy of the objects on which they may be bestowed.

The foregoing may be considered, then, the general objects of the Institute, which are, in few words, the promotion and encouragement of the art and science which the Founders profess, by all the means in their power. It is their desire, more especially, to advance these objects by acting in concert with all other Institutions, both at home and abroad, with whom there exists a community of sentiment; and to disclaim at the same time, most decidedly, interference with any existing establishment.

REGULATIONS

OF THE

INSTITUTE OF BRITISH ARCHITECTS.

SECTION I. OF ITS OBJECT.

The Institute of British Architects has been founded for facilitating the acquirement of architectural knowledge, for the promotion of the different branches of science connected with it, and for establishing an uniformity and respectability of practice in the profession.

SECTION II. OF ITS CONSTITUTION.

The Institute of British Architects shall consist of three Classes of Members; Fellows, Associates, and Honorary Members.

The Fellows shall be Architects who have been engaged as Principals for at least seven successive years in the practice of Civil Architecture.

The Associates shall be persons engaged in the study of Civil Architecture or in practice less than seven years, and who have attained the age of twenty-one years. They are to be privileged to attend all Meetings of the Institute, but to have no vote respecting its affairs, nor to join in any other discussions than those relating to subjects of art and science.

The Honorary Fellows shall consist of Noblemen, who shall contribute a sum at one time of not less than twenty-five guineas, and of Gentlemen unconnected with any branch of building as a trade or business, who shall contribute a like sum. Persons also eminent for their works or scientific acquirements, not being British Architects, and resident either abroad or in the United Kingdom, who may be duly elected on that account, will be placed in the class of Honorary Members without contribution. They will have the privilege of being present at all ordinary Meetings, and that of access to the Library and Museum.

SECTION III. OF THE OFFICERS.

The Officers of the Institute shall consist of a President, three Vice-Presidents, and two Secretaries, who, with seven other Members, shall form a Council for the direction and management of its affairs. The above officers and council must always be chosen from the first class of Members, except the President, who may be elected from the class of Honorary Members.

SECTION IV.

OF THE ELECTION OF FELLOWS, ASSOCIATES, AND HONORARY MEMBERS.

All persons desirous of being admitted Fellows or Associates must be proposed agreeably to the form in the Appendix (No. I.), wherein must be inserted the Christian name, Surname, and usual place of residence of the candidate, and this form must be subscribed by at least three Fellows, who shall certify their personal knowledge of the individual.

Every recommendation of a candidate must be delivered to the Secretary, who shall submit the same to the Council; if they shall find the candidate qualified according to the regulations of the Institute, the proposition shall be signed by the Chairman of the Council: it shall then be read at the first following Meeting, after which it shall be hung up for two successive Meetings, and the candidate shall be balloted for at the third.

Every person proposed as an Honorary Member, (Noblemen and Gentlemen of this Class excepted,) must be recommended by at least three Fellows who must certify that he is a person eminent for science, and give the title of any works he may have written, which may entitle him to such distinction, pursuant to form No. II.

The nomination of all Honorary Members must be approved by the Council, and the election take place at the first subsequent General Meeting.

The proportion of votes requisite for the election of any person shall be at least four-fifths of the ballot.

No person shall be balloted for a second time, within a period of twelve calendar months, if not elected on the first ballot.

When a person is eligible from the list of Associates to become a Member of the first Class, he must be balloted for on the proposition of three Fellows, and go through the same forms of ballot as a candidate for election as Fellow. (See Appendix No. III.)

In case of the non-election of any person balloted for, no notice shall be taken thereof in the Minutes.

When a person is elected into any of the Classes, the Junior Secretary shall immediately inform him of the same by letter, (Appendix No. IV.,) as the case may be, and no Fellow, Associate, or Honorary Member, shall be considered entitled to the rights and privileges of his particular class, until he shall have signified his acquiescence in the election.

Every person elected a Fellow or Associate of the Institute shall pay his first annual contribution or composition within two months of the day of his election, otherwise such election shall be void.

Every Fellow and Associate, except those resident more than twenty miles from London, shall as soon as possible after election, be required to sign the form No. IV. in the Appendix, and having likewise paid his composition or first annual contribution, as the case may be, shall be admitted at the first Meeting of the Institute at which he is present, which must not exceed five months from the day of his election, if he be within the United Kingdom, according to the ensuing form, viz.:

The President addressing him by name shall say—"As President of this Meeting, I hereby admit you a Fellow [or otherwise according to his Class] of the Institute of British Architects."

The following shall be deemed grounds for the expulsion of any Fellow or Associate, viz. for having engaged since his election in the measurement, valuation, or estimation of any works undertaken or proposed to be undertaken by any building artificer, except such as are proposed to be executed or have been executed under the Member's own designs or directions; or for the receipt or acceptance of any pecuniary consideration or emolument from any builder or other tradesman whose works he may have been engaged to superintend; or for having any interest in, or participation with, any trade, contract, or materials supplied at any works, the execution whereof he may be or have been engaged to superintend; or for any conduct which, in the opinion of the Council, shall be derogatory to his professional character. Such proposition shall be entertained and judged of and determined by the Council only. No Fellow or Associate shall be expelled unless seven of the Council concur therein, and if they so concur, the Member shall be considered expelled on the President announcing such determination of the Council to the next ordinary meeting which shall be held, and the junior Secretary shall forthwith communicate the same to such Member according to form No. V. in the Appendix.

Upon any Member dying, ceasing to be a Member, or being expelled, as

herein before mentioned, all his share and interest of and in the stock, property, and effects whatsoever of the Institute, shall absolutely cease and determine.

SECTION V. OF THE ELECTION OF OFFICERS, AND OF THE COUNCIL.

The President, Vice-Presidents, and Secretaries, and the other seven Members of the Council, shall be elected annually by ballot at the General Meeting, which shall be held on the first Monday in May.

No Member who has filled the office of President for two successive years shall be again eligible to the same situation, until the expiration of one year from the termination of his office.

Two only of the Vice-Presidents are to be re-eligible each year.

Four only of the seven other Members of the Council who may have served during any one year can be re-elected for the ensuing year.

SECTION VI. OF THE CONTRIBUTIONS OF MEMBERS.

Every nobleman or gentleman, who may present the Institute with a sum of not less than twenty-five guineas, may be elected an Honorary Fellow.

The contributions of the Fellows shall be five guineas for admission, and three guineas annually; or a Fellow may at his entrance compound for his contributions by the payment of thirty guineas, or, at any time after the first year, by a payment of twenty-five guineas.

The Associates shall pay three guineas for the first year, and two guineas for every subsequent year. This class cannot compound for their annual subscription.

The Honorary Members elected for their scientific or architectural acquirements, are not expected to contribute to its funds.

All annual payments shall become due on the first of January, and shall always be paid one year in advance. Any Member admitted after the Michaelmas of any year, will not be required to make his first payment before the first day of the subsequent January.

Every Member, except Honorary Members, shall be liable to the payment of his annual contribution, and to all the official acts of the Institute, until he has either forfeited his claim, or has signified in writing to the junior Secretary his intention to resign, when his name shall be withdrawn from the List of Members.

Whenever any Member shall be two years in arrears in the payment of

his annual contribution, the junior Secretary shall send such Member a letter of the Form No. VI. in the Appendix; and if the arrears shall not be paid within six months after the forwarding of such letter, such default shall be publicly notified at the next ordinary Meeting of the Institute, together with the amount of contribution due by him; and such Member shall not enjoy any of the privileges and advantages of the Institute until his arrears be paid.

SECTION VII. OF THE COUNCIL.

The Council shall have the management and direction of all the affairs of the Institute, subject to the control of the General Meetings. The Council shall meet at the apartments of the Society at least once in every month during the session, but any three Members of the Council may, by letter to one of the Secretaries, require an Extraordinary Meeting to be called. Due notice of each Meeting of the Council shall be sent by one of the Secretaries to every Member thereof residing within the limits of the threepenny post.

At Meetings of the Council, three Members shall constitute a quorum.

All questions shall be decided in the Council by vote, unless a ballot be demanded. The determination of the Council, whether by vote or ballot, shall, at the desire of any two Members present, be deferred to the succeeding Meeting.

The Council shall draw up a Report on the state of the property and affairs of the Institute, to be presented to the Annual General Meeting, which shall give an abstract of their proceedings during the year, and an account of the funds, including a balance sheet, properly audited, of receipts and disbursements.

SECTION VIII. OF THE PRESIDENT AND VICE-PRESIDENTS.

The duty of the President shall be, to take the chair at the Meetings, and to regulate and keep order in all the proceedings of the Institute; to state and put questions according to the sense and intention of the Meetings, and to carry into effect the regulations of the Society.

In the absence of the President, the Vice-Presidents in rotation, (or in their absence, one of the Members of the Council,) shall take the chair and conduct the business of the Meeting; and in case of the absence of all those officers, the Meeting may elect any other Fellow to take the chair.

SECTION IX. OF THE SECRETARIES.

The duties of the Secretaries shall be, to attend all Meetings of the Society and of the Council, to take minutes of all their proceedings, and enter them in the proper books provided for that purpose.

Their duties at the ordinary Meetings shall be, to read the minutes of the preceding Meeting; to announce the donations made to the Society since the last Meeting; to give notice of any Candidate that is proposed for admission or that is to be balloted for; and to read letters and papers presented to the Society, in the order of time in which they were received, unless the Council shall otherwise direct. All Papers must be submitted to the Council before being read at the ordinary Meetings. Should any person be desirous of reading his own paper, he shall be permitted to do so with the consent of the Council.

The Secretaries shall have the superintendence of the persons* employed by the Institute, and the management of the correspondence of the Institute and Council, subject, however, to the discretion and control of the latter.

The Secretaries shall have the charge, under the direction of the Council, of printing and publishing the Memoirs or other papers of the Society.

SECTION X. OF THE AUDITORS.

One Fellow and one Associate shall be annually appointed as Auditors, to audit the accounts of the Institute, and report thereon to the General Meeting.

* OF THE LIBRARIAN.

To be under the control and direction of the Secretaries.

To assist them generally in all their duties.

To attend at the Rooms from 11 to 5 daily, and three evenings a week from 7 to 10, during the Session of the Institute, excepting one week at Christmas and one at Easter.

To consider the whole of his time during such attendance to be devoted to the purposes of the Institute.

To be in attendance during all Meetings of the Members, and to take notes, &c. of such proceedings.

To keep the minutes of the proceedings, and enter the same in the books, to keep all accounts, to prepare notices of meetings, to make drawings at large, or to a reduced scale, connected with the papers communicated to the Institute.

SECTION XI. OF THE TREASURER.

The Treasurer shall be a banker in London or Westminster, with whom all money belonging to the Institute shall be deposited by the Council, on account and for the use of the Institute.

No sum of money payable on account of the Institute shall be paid, except by order of the Council, signed by three Members thereof and one of the Secretaries.

Twenty-five guineas of each composition, the contributions of Honorary Members, and the surplus of the income after the payment of the current expenses, are to be invested in Government Securities, the interest only to be available for the current disbursements, and no portion is to be withdrawn unless with the sanction of a special general meeting.

SECTION XII. OF THE PROPERTY OF THE INSTITUTE.

The whole of the effects and property of the Institute shall be vested in three Trustees for its use, to be chosen at the Annual General Meeting.

Every paper which may be presented to the Institute shall, in consequence of such presentation, be considered the property of the Society, unless there shall have been any previous engagement with its Author to the contrary; and the Council may publish the same in any way and at any time that they may think proper. But should the Council refuse or neglect, within eighteen months from its reception, to publish such paper, the Author shall have a right to copy the same, and publish it under his own directions. No other person, however, shall publish any paper belonging to the Society, without the previous consent of the Council.

SECTION XIII. OF THE ORDINARY MEETINGS.

The Sessions of the Institute shall commence annually on the first Monday in December, and ordinary Meetings shall be held on every alternate Monday (Christmas, Passion, and Easter weeks excepted) until July inclusive; but it shall be in the power of the Council to protract the Sessions, should it appear necessary. The chair to be taken as soon after eight o'clock as there shall be five Fellows present, and the business of the Institute shall commence forthwith.

Every Fellow, Associate, and Honorary Member shall have the privilege

of introducing one Visitor, to be present at the public business of the Institute, on writing the names of such Visitors in a book to be provided for that purpose.

At the ordinary Meetings no question relating to the regulation or management of the Institute shall be brought forward, and no motion shall be made after ten o'clock.

SECTION XIV. OF THE ANNUAL GENERAL MEETING.

A General Meeting of the Institute shall be held annually on the first Monday in May, at three o'clock in the afternoon, to receive and deliberate upon the Report of the Council on the state of the Institute, and to elect the Officers for the ensuing year.

SECTION XV. OF SPECIAL GENERAL MEETINGS.

The Council may at any time call a special General Meeting of the Institute for a specific purpose, and they are at all times bound to do so on the written requisition of eight Fellows, which shall specify the nature of the business to be transacted.

No alterations of the rules or regulations shall be made, except at a special General Meeting of Members, who shall have, if resident in London, at least five days' notice of the time of such Meeting, and shall at the same time be informed of the nature of the business to be brought forward; and no other question shall be discussed at such Meeting.

SECTION XVI. OF COMMITTEES.

The Council shall have power to appoint Committees, for the purpose of investigating specific subjects connected with the objects of the Institute; and the reports of such Committees shall be submitted to the Council previously to their being read to the Institute.

SECTION XVII. OF ALTERING THE REGULATIONS.

The Council shall, when they consider it expedient to propose the enactment of any new regulation, or the alteration or repeal of any existing one, summon a Special General Meeting of Members to decide on the same; and

the Council may also call a Special General Meeting at any time during the Session for such purpose.

The alteration or repeal of any existing regulation may be recommended to the Council, such recommendation to be written out and signed by any eight Fellows, and the recommendation being thus made, the Council shall decide on the propriety of submitting such proposition to a General Meeting. If such decision be not satisfactory to the Fellows proposing the alteration, the Council shall, if required by them, submit the same to a Special General Meeting of Members to be convened for that purpose.

No new regulation, alteration, or repeal of any existing regulation, shall be proposed at any meeting of the Institute except in the manner here described.

SECTION XVIII. OF THE BYE-LAWS.

The Council shall have power to make such bye-laws and ordinances, not, however, repugnant to the spirit and intention and meaning of the regulations nor contrary to the laws of the realm, as circumstances shall in their opinion from time to time render necessary, for the good order and government of the Institute.

SECTION XIX. OF DONATIONS AND BEQUESTS.

Every person who shall contribute to the collection, to the library, or to the general funds of the Institute, shall be recorded as a Benefactor; his name shall be read at the Annual General Meeting, and shall be inserted in the next volume of the Memoirs of the Institute thereafter published.

Every person desirous of bequeathing to the Society any Manuscript, Books, Sculptures, Casts, Models, Pictures, or Instruments, is requested to make use of the following form in his will, viz.

> " I give and bequeath to the Trustees for the time being of the " Society formed in London, under the title of the Institute of " British Architects," [here enumerate the effects or property intended to be bequeathed] " for the use of the said Society; and I " hereby declare that the receipt of the Treasurer of the said So- " ciety shall be an effectual discharge to my executors for the said " Legacy."

Every person desirous of bequeathing to the Society a sum of money or stock, either for the general purposes of the Society, or to establish a prize for the best production, or any particular subject connected with Architecture, is requested to make use of the following form in his will.

> " I give and bequeath to the Trustees for the time being of the " Society formed in London, under the title of the Institute of " British Architects, the sum of , for the use of the " said Society, and for the purpose of " [here express the particular object in view, if any,]. " And I hereby declare, that the " receipt of the Treasurer of the said Society shall be a final dis- " charge to my Executors for the said Legacy."

APPENDIX.

No. I.

A. B. of , being desirous of being admitted a [here state the class into which the party is proposed for admission] of the Institute of British Architects of London, We, the undersigned, do, from our personal knowledge of him, [or his works, if a corresponding Fellow,] propose and recommend him to the Council for ballot.

Witness our hands this day of

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No. II.

We, the undersigned, Fellows of the Institute of British Architects of London, do hereby nominate and recommend to the Council for election as Honorary and Corresponding Member, of , his works being known to us, and of sufficient importance to entitle him to such distinction.

Witness our hands this day of

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No. III.

We, whose names are hereunto subscribed, submit to the Council of the Institute of British Architects, the propriety of removing *A. B.* from the class of Associates to that of Fellows, and request a ballot of the Fellows may be had thereon.

Witness our hands this day of

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No. IV.

SIR,

I have the pleasure to inform you, that on you were elected a [as the case may be] of the Institute of British Architects; in conformity with the regulations. It is necessary previously to your admission that the enclosed Form signed by you be returned to me, and that your first annual contribution of , or composition of for annual payments, be paid forthwith to the Treasurer of the Institute, as unless it be paid within two months, your election is void. I am therefore to request that you will take the earliest opportunity of so doing.

I have the honour to be,

Sir,

Your obedient humble servant,

FORM TO BE SIGNED.

I, the undersigned, being elected a of the Institute of British Architects, do hereby promise and engage, that I will be governed by the regulations and bye-laws of the said Institute, or as they may be hereafter altered, amended, or enlarged; and that by every lawful means in my power I will advance the objects of the said Institute, and will attend the Meetings thereof as often as I conveniently can: provided that, whenever I shall signify in writing to one of the Secretaries for the time being that I am desirous of withdrawing my name therefrom, I shall (after payment of any arrears, which may be due by me at that period) be free from this obligation.

Witness my hand this day of

No. V.

SIR,

IT is my duty to inform you that, by a resolution of the Institute of British Architects, pursuant to regulations, Section IV., you are no longer a Member of that body.

I am,

Sir,

Your obedient humble Servant,

No. VI.

Sir,

The Council of the Institute of British Architects have directed me to inform you, that your contribution thereto has been in arrear since , the amount being .

I have therefore to request that you will immediately cause the same to be paid.

I am,
Sir,
Your obedient humble Servant,

REPORT OF THE COUNCIL.

Read at the Annual General Meeting, held Monday, 22nd of May, 1836, drawn up by P. F. Robinson, V. P.

The great advantage arising from the union of professors in any particular art or science, and the good results produced by the intercourse thus established, experience has long shewn. This has been most satisfactorily proved during the last year with respect to this Institute, and it is a subject of much gratification to all interested in its prosperity, to witness the exertions used and the success consequent upon those exertions. Ever since the establishment of a Royal Academy in England, but more particularly during the last thirty years, many observations have been made as to the propriety of inviting the Architects of Great Britain to form themselves into a Society for the purpose of promoting the cultivation of the art, and maintaining the respectability of its professors, considering the Royal Academy as composed almost wholly of Painters and Sculptors, whose views are naturally confined to their own particular study. The very severe reflections, which from time to time, and more particularly of late years, have been cast against the Architects of the present day, and the opinion too generally entertained by the public, that the art is but little understood, has at length roused its professors to some exertion, and without the smallest feeling of hostility towards the Royal Academy, rather indeed with the most cordial desire to forward the true interests of art by seconding the endeavours of that distinguished body, in adopting every genuine means likely to promote its advancement, our "Institute" has burst into existence.

Whether the animadversions against the profession have been deserved or not, we should hope it may admit of some doubt: yet, although much has been done towards the improvement of London, the style of architecture is not in all cases so pure as could have been desired. The cause may be difficult to solve, and yet we are inclined to consider it mainly attributable to that system of exclusion so severely practised for some years past, by which the great body of the profession has been entirely shut out from all chance of obtaining any portion of the public works. The injury done by thus closing the door to exertion was manifest, the good arising to the

public, certainly problematical. As a proof of the advantage produced by public competition, we need only refer to the struggle, which has recently taken place with regard to the designs for the new Houses of Parliament, the productions having exhibited the talent of the day in a most favorable point of view, and no one can doubt but that many of the Architects, whose works now form the exhibition at the National Gallery, will most honorably acquit themselves, when called upon at any future time to superintend works of the highest class of art.

Indeed, it is with feelings of pride and satisfaction, the Council reflect upon the circumstance that two of the prizes have been gained by members of our Institute, Messrs. Barry and Railton, the former of whom has been selected as the most successful candidate, his design being approved by the Commissioners, and adopted by the Legislature. The event is of no ordinary description, and we have no doubt the result will prove honorable to the Architect, and creditable to the country.

Another competition has occurred at Cambridge, designs having been required for erecting the Fitzwilliam Museum. In this instance also, the prize was adjudged to Mr. Basevi, a member of the Institute.

A distinction has likewise been conferred upon a member of our body, alike honorable to the individual and complimentary to the Institute, and in drawing the attention of the meeting to the circumstance of our Hon^{ble}. Sec^{y}. Mr. Thos. Leverton Donaldson having been elected a corresponding member of the Institute in Paris, and of the Academy of Fine Arts at Parma, the Council feel assured how greatly these events will contribute to the general satisfaction.

Some years since, on a memorable occasion, a report of the House of Commons expressed in strong terms an opinion, that no Architect could be found in this country capable of carrying a great work into effect; it was well known at the time, that the charge brought against the profession was most injurious and unwarrantable, and the recent event, when ninety-five men sat down to the consideration of the same subject, has sufficiently disproved those conclusions. Were it possible to have models made of the various designs now exhibiting, the public would be better able to judge of the comparative merits, and some idea may be formed of the effect such an exhibition would produce, by referring to those in the Bodleian Library at Oxford, and to some preserved in Westminster Abbey, but which are inaccessible to public inspection. A model conveys so perfect an idea of the object contemplated, that we anxiously look forward to the time when we may possess a museum enriched with representations of the most celebrated

buildings of ancient Greece and Rome, with those of our own country, made to the same scale.

The difficulties which an Architect has to encounter in carrying a great work into effect, few but practical men can understand, and it may not be considered irrelevant here to observe, how unpleasant his situation frequently becomes, from the dictatorial opinions pressed upon him. Every one considers himself competent to advise, and the Architect is too frequently made responsible for the errors of his employer,—innumerable instances may be adduced; but, without alluding further to a subject already much debated, we ardently hope, that in the erection of our intended Houses of Parliament, the Architect will be left to the free exercise of his own judgment, uncontrolled and unshackled in matters of art by the opinions of others. The Amateur may form some opinion of the general effect of a design, but it is the practical man alone, who understands the effects he proposes to create, and the means by which they are to be produced, and the result should be the operation of one head and one mind, in order to form a perfect whole.

The observations daily occurring in the pursuit of a favorite study, and the results arising from a devotion to one subject, are lost to the world, while enclosed in the portfolio of an individual, but as the member of a Society, the varied efforts of his imagination become the property of the public, and he is tempted to enter the arena, stimulated by an honorable desire to contribute his mite towards the general good. This feeling has been productive of the happiest results, for although a Society of this nature is so novel a feature in the profession, and the Members have had hitherto few inducements to communicate publicly the results of their practical experience, yet there has never occurred a period from the opening meeting at which there has been a deficiency of matter, at once useful and interesting. Communications have flowed in from all parts, and it is hoped that the Members will still continue to contribute such papers as may keep up the interest of the meetings, and prove useful in disseminating knowledge throughout the profession. The Council have made a selection of the most important of the papers read, and have made arrangements for their publication in the first part of the first volume of their Transactions. They cannot hope to present to the profession and to the public, that mass of intelligence and novel information, which a longer existence as a Society, may, they trust, in time produce. Still they propose sending forth their first part as a pledge to their Correspondents of the use they purpose making of their communications, and as a proof that zeal and assiduity have not been wanting

on the part of the Members to render the Institute an useful association for the promotion of the Science.

The progress of the Institute since its first establishment in the year 1834 has realised the fondest wishes of its warmest friends, and we have now the satisfaction of enumerating among its Members, the greater number of the principal Professors of the present day. In making this observation, it is proper to remark, that the Architects attached to the Royal Academy have not yet joined us, but as they have all expressed the same friendly feeling and a disposition to forward our interests, the day, it may be hoped, is not far distant, when they may consider it not incompatible with their duties as Royal Academicians, to add their distinguished names to our list.

The correspondence, opened with the most celebrated professors in every part of Europe, has already been productive of beneficial results, and as the invitation to join our Society has invariably been met by a reciprocal feeling on the part of all those, who have up to this time been addressed, there is every reason to expect the good feeling will increase. The benefit arising from this communication has already been proved in the instance of Members projecting a tour on the Continent, as official letters of introduction to our foreign Correspondents may at all times be obtained from our Honorary Secretaries. To those young men, who have not yet prosecuted their studies on the Continent, this must be an advantage of no ordinary description, and cannot be too highly appreciated.

A letter has recently been received from Mr. Colquhoun, Agent and Consul General of the Hanse Towns, proposing that facilities should be afforded to Architects from Lubeck, Bremen, and Hamburgh, visiting London, upon a recommendation from him to our Secretary, provided similar facilities are afforded to English Architects visiting the Hanse Towns by the authorities there. The same may also be observed with respect to subjects of the King of Saxony, whose Consul General Mr. Colquhoun also is. The importance of this communication need scarcely be observed, as it will be a precedent for similar applications to other authorities, all tending to enlarge the sphere of our usefulness.

But there is reason to hope, looking to the presents already received, and arguing from the warmth of expression invariably adopted by all our Correspondents, that other advantages may be derived from this source. Independent of the means of information thus within our reach, we may presume that drawings, and even models, may from time to time be procured, of all the most celebrated buildings, both ancient and modern, and that our model room, now in an embryo state, may soon become the resort

of all distinguished for a love of Architecture. Thus the public may, by degrees, acquire some knowledge of a profession classed by universal consent, and by the suffrages of mankind from the earliest ages, among the most liberal.

The contributions already received have been so considerable, that our rooms are scarcely sufficient to receive them, and some steps must be taken in order to obtain more space. In the hope that the Government will notice the application lately made on this subject, the Council are unwilling at present to do more, but much time cannot be allowed to pass before a new arrangement may be desirable. The specimens of stone applicable to building purposes daily increase, and form a very interesting feature: and since the very important step taken by the Council in establishing lectures on Geology, this collection has increased in value. The Government having determined upon forming a Museum for the reception of specimens obtained by the officers employed on the Geological survey of Great Britain, and as it is intended this collection shall contain specimens of the various mineral substances used for roads, and in the construction of public works and buildings, arranged with reference to the situations whence they were obtained, duplicates may be procured and exchanged, and reciprocal advantages brought about by such an interchange. As durability is of the first moment, portions of stone taken from our ancient buildings, having been exposed to the atmosphere, will be particularly desirable, as the period may, in most cases, be ascertained how long such stones have been thus exposed; but, in making this proposition, the Council deprecate in the strongest terms any spoilation, or attempt to remove even the smallest portion of that, which now forms an integral part of the building, spoilations which no true lover of ancient art would for a moment tolerate. Sufficient for the purpose here alluded to, will at all times be found when repairs have been made, or among the debris or mere rubbish, particularly in our desecrated buildings. If in addition, specimens of the mortar can also be procured, the conclusions will become still more satisfactory. As a commencement to this collection, portions of the masonry from Clifford's Tower in York, and from the White Tower in London, have been placed in our room, with some of the ancient mortar attached. In many instances, the drilling and sculptured parts on the northern sides of our Cathedrals, remain in the most perfect state, unimpaired by time.

The portraits which adorn our walls, it is hoped, may be considered as the commencement of a series, it being extremely desirable we should obtain those of all the most distinguished Architects who have preceded us.

In addition to that of Sir Robert Taylor, presented last year by Mr. Cockerell, R.A. we have now the satisfaction of seeing that of James Wyatt, presented by Mr. Rhodes, one of Nicholas Revett by Mr. Weale, and that of Sir John Soane presented by himself.

The beautiful series of drawings left by the late Mr. Parke has been presented by the widow for the use of the Institute, and the Council congratulate the Society upon the possession of this valuable collection. It consists of between five and six hundred drawings, being measured sketches of buildings in Italy, Sicily, and Egypt, some of them drawn out to a scale, but all delineated with that precision and masterly execution for which Mr. Parke was so pre-eminent.

Mr. Benjamin Wyon has undertaken to prepare a medal, designed expressly for the use of the Institute, having the Temple of Theseus on the obverse, and a wreath with an inscription on the reverse. It is intended as a prize medal, to be given annually; the Soane medal being occasionally given.

The liberality of our noble President, in opening his house to the members of the Institute, cannot be too highly appreciated, and it is with no ordinary feelings the Council allude to a circumstance, which has given rise to similar meetings at the houses of several members of the Council. These have been productive of much intercourse of the most gratifying description, and the cordiality, thus brought about among members of the same profession, forms an interesting and peculiar feature in our Society.

In expressing their regret for the loss of our late Treasurer, Sir Thomas Harvie Farquhar, Bart., the first of our Honorary Members, the Council have to announce, with much satisfaction, that his son Sir Walter Rockcliffe Farquhar has been pleased to accept the appointment. Another loss has occurred in the person of our late Associate Mr. James Ashley, who attended for some time as our Librarian, and whose assiduity and attention were of great use at an early period of our operations, when the personal co-operation of the members was of the utmost value and importance.

The munificent donation from Sir John Soane having been placed in the Bank of England, a fund has been established, to which liberal additions have been made, giving stability to the Society. The present state of our finances will appear from the balance sheet, and it is with much pleasure the Council have to draw the attention of the Society to this part of our subject.

Statement of the Receipts and Expenditure for the Year ending May 4th, 1836.

RECEIPTS.

		£.	s.	d.
1835 and 1836.	Balance in Treasurer's hands, May 1835		342	3	8
	Contributions of seven Fellows	£36 15 0			
	Subscriptions of forty-six ditto	144 18 0			
			181	13	0
	Contributions of four Associates	4 4 0			
	Subscriptions of sixteen ditto	33 12 0			
			37	16	0
	Annual Subscription of a Friend		1	1	0
	Ditto ditto by J. Newman, fellow (for travelling fund)		2	2	0
	COMPOSITION:—				
	W. Burn		31	10	0
	DONATIONS:—				
	Earl de Grey	£50 0 0			
	Peter Legh, Esq.	26 5 0			
	Joseph Neeld, Esq.	26 5 0			
	Sir John Soane	750 0 0			
	J. Morrison, Esq. M.P.	50 0 0			
	C. Morrison, Esq.	25 0 0			
	W. Nurse, Esq.	26 5 0			
	C. Barry, Esq.	20 0 0			
	J. Noble, Esq.	5 0 0			
	S. Kempthorne, Esq.	5 0 0			
	J. J. Scoles, Esq.	5 0 0			
	T. Bellamy, Esq.	10 0 0			
	J. Newman, Esq.	10 10 0			
	G. Moore, Esq.	20 0 0			
	W. Leverton, Esq.	10 0 0			
	J. B. Gardiner, Esq.	10 10 0			
			1049	15	0
	DIVIDENDS on £1100. three per cents. half-year due January		16	10	0
	Contribution and Subscription of four Fellows	33 12 0			
	Donation	10 0 0			
			43	12	0
			£1706	2	8

DISBURSEMENTS.

		£.	s.	d.
1835 and 1836.	Sir Henry Richardson, for One Year's Rent, due Lady-day last	100	0	0
	Purchase of £1112. 13*s.* 1*d.* reduced three per cents.	1006	8	6
	Books, Prints, &c.	84	8	0
	Stationery	6	3	0
	Printing, &c.	57	15	6
	Writing	18	12	1
	Furniture	91	0	5
	Oil, &c.	5	5	3
	Advertisements	16	0	6
	Attendance	18	0	0
	Petty Disbursements	21	13	10
	Librarian's Salary	8	6	8
	SUNDRIES:—			
	Engraving, Bookbinding, Insurance, &c.	46	14	3
		£1483	8	0
	Errors	0	12	3
		1482	15	9
	Balance in Treasurer's hands	223	6	11
		£1706	2	8

We, the Auditors, have examined this Account, and find a Balance of £223. 6*s.* 11*d.* in the hands of the Treasurer.

THOMAS CUNDY,
CHARLES EVANS LANG.

JOHN GOLDICUTT, *Hony. Secretary.*

The Council have to congratulate the Institute upon the gradual increase of its members, four-and-twenty having been elected since the general meeting in May 1835.

About 108 volumes have been added to the Library, eighty-four of which were presents. The stock of prints has been increased by fifty-seven, seven of which only have been purchased, and the greater portion of the others are of the most valuable description. Seven fragments of sculptured marbles from Greek and Roman buildings, of the finest style of art, and one hundred and twenty-nine casts now enrich this portion of our collection. Between four and five hundred specimens of stones and marbles used in construction are due to the generosity of the Members and friends of the Institute. Two models, both executed by Mr. Deighton in his most exquisite manner, some portraits, busts, framed drawings, and above 200 medals, more particularly specified in the accompanying list of donations, prove that the appeal to the Profession and to the lovers of art has not been in vain, and that we may continue to hope the addition of further gifts, which cannot fail of rendering the Library and Collection of the Institute important to the Profession, as affording great facilities for reference.

The Council consider that they cannot better close this brief summary than by submitting, agreeably to the nineteenth section of the Rules and Regulations, the list of those Donations which have been made to the Institute.

CONTRIBUTORS

TO THE COLLECTION, TO THE LIBRARY,

OR TO THE

GENERAL FUNDS OF THE INSTITUTE.

Messrs. Percier and Fontaine, Honorary and Corresponding Members. A complete Series of their Works, viz.—Palais et Maisons de Rome, folio. Les Villas d'Italie, folio. Recueil de Meubles et Ornemens, folio. Le Sacre de Napoleon, folio. Le Marriage de Napoleon, folio. L'Arc du Carousel, folio. La Chapelle du Cimetière de la Madeleine, folio. Les Residences de Souverains, 4to. L'Histoire du Palais Royal, 4to.

Jas. Elmes, Esq. A copy of his work on the Law of Dilapidations. A copy of another on Architectural Jurisprudence. Proof prints of Scriven's Portrait of Sir Christopher Wren, and seventy-six other Architectural prints. A curious Map of London, shewing the extent of the great Fire, and the Edifices built by Sir C. Wren.

W. S. Inman, Fellow. Philosophical Transactions of the Royal Society from 1665 to 1800, abridged by Hutton, Shaw, and Pearson, 18 vol. 4to. Transactions of the Society of Arts, 36 vol. 8vo and 1 of Index. Two vol. of Reports of House of Commons. Two Parliamentary Reports upon Bogs in Ireland. Various specimens of Stones, &c. Specification of Works for erecting the London Orphan Asylum at Clapton. Recherches sur les Mortiers, par Vicat. Cast of the Lion's Head from the Pantheon, Athens, from the frieze of the Temple at Tivoli, &c. &c. Report of the Committee of the House of Commons on Ventilation, Warming, &c. abbreviated with notes by the Donor, 8vo 1836.

P. F. Robinson, V.P. Copy of his work on Mickleham Church. Various specimens of Stone from Yorkshire. Thirteen Gothic Casts from St. Mary's Abbey, Yorkshire.

J. B. Papworth, Fellow. Model of the Temple at Edfou, as restored by Napoleon.

Lord de Grey, President. Copy of Report to Admiralty respecting Kyan's Patent for prevention of Dry Rot in Timber.

George Moore, Fellow. Twenty pounds in cash for general purposes.

J. W. Hiort, Esq. Harrow on the Coach-head Arch, folio, 1768, with models of ditto. Volume of original sketches and drawings made about the year 1698, by J. Talman, Architect. Copy of Loader's Geological Map of England and Wales, mounted. Pasley on Brickwork, 4to M.S. lithographed. Hiort's Treatise on the Architectural construction of Chimnies, large 8vo with coloured plates and models. Pamphlets with models and specimens illustrative of various Building Materials invented by J. W. Hiort, 8vo.

Captain Carnegie. A Vase turned out of the Arbroath Stone by Hunter's Patent Machine.

James Morrison, Esq. M.P. Fifty pounds.

William Leverton, Esq. Ten pounds.

A Friend, by T. L. Donaldson. Annual, One Guinea.

Robert Upton, Esq. Palladio's Architecture, folio, London.

Sir Henry Ellis. Copies of various papers on Architectural subjects, published in the Archælogia.

Philip Hardwick, Fellow. Cast of the Capitals of the Column and Pilaster of the Erectheum at Athens, and numerous other Casts of Gothic Ornaments from the old Hospital of St. Katherine. A suite of twenty-eight specimens of Marbles to one size, labelled. Also, a great quantity of other specimens, some labelled, others not so. And specimens of Asphaltic Mastic used in Paris for pavements, &c.

Mr. Williams. Murphy's Batalha, folio, plates, London, 1836.

John Goldicutt, Honorary Secretary. Copy of Philander's Vitruvius, 4to 1550.

Samuel Angell, Fellow. Copy of his work on the Metopes of the Selinuntine Temples, folio, London.

Henry Rhodes, Fellow. Portrait of the late James Wyatt, Architect. Specimens of Stone. Copy of the Laws and Regulations of the Academy of Fine Arts in New Spain.

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COMMUNICATIONS.

CONSTRUCTION.

The Institute do not hold themselves responsible for the several facts, opinions, and statements, contained in the communications of their Correspondents.

Prize Essay upon the Nature and Properties of Concrete, and its application to Construction up to the present period,

TO WHICH WAS AWARDED THE MEDAL OF THE INSTITUTE ON THE 18TH JANUARY, 1836.

By GEORGE GODWIN, Jun. Associate.

" Auxilia humilia firma consensus facit."

" And the rain descended, and the floods came, and the winds blew, and beat upon that house; and it fell not, for it was founded upon a rock."—Matthew vii. 25.

To say that no portion of construction offers more claims to the consideration of the Architect, nay, more loudly demands it, than the foundation on which he is about to raise his superstructure, is but to echo an often repeated and always admitted truth; the many failures, however, which have occurred and are constantly occurring through inattention in this particular—evidences at the same time, were they needed, in favor of our first position—clearly prove not only that it may be useful again to urge it, but that it cannot be too often, or too strongly impressed upon the understanding of the young architect. Every endeavour should be made, in the first place, thoroughly to ascertain the nature of the soil, for no difficulty can well be overcome until it be properly understood. It is therefore with judgment advised by some of the old writers upon the subject, that, before preparing the foundation, the wells and cesspools necessary for the purposed edifice should be dug; the description of soil to some considerable depth is thus discovered, and, with this before him, the architect may almost safely determine upon the precautions necessary to be adopted. Whatever the measures resolved on may be, they should always be carried into execution well and thoroughly, sparing neither pains nor cost, as it is self evident, that at no other period than at the commencement, can the all-involving desideratum, a good foundation, be attained in any moderate degree without an amazing increase of outlay, nor even can any partial reinstatement be made but at considerable inconvenience and expense.

Of the attention paid by the ancients to the preparation of their foundations, those splendid monuments of intelligence and power left us by them, which, exposed during centuries, have braved the destroying influence of

time and season, and remain, so far as regards construction, perfect as when first erected, afford the most indubitable evidence.* Many of the temples, being built upon a rock, needed hardly any preparation; most of them however were erected on spots hallowed by peculiar events or circumstances, without regard to an eligible situation, some even in marshes, and display the greatest ingenuity and science in that particular. Josephus, describing the building of the temple at Jerusalem by Solomon, commenced probably 1012 B. C., says, "The foundations were laid prodigiously deep, and not only were the stones of the largest size, as had been ordered, but they were of the hardest description; firm enough to endure all weathers, and proof against the worm; besides which *they were all morticed one into the other, and wedged into the rock.*"†

We find also, that of the house built by Solomon for Pharoah's daughter, "whom he had taken to wife, the foundation was of costly stones, even *great* stones; stones of 10 cubits and stones of 8 cubits."‡

In order to form a port between Dora and Joppa, Herod, in the fifteenth year of his reign, (so it is recorded by Josephus) ordered mighty stones to be cast into the sea at 20 fathoms water, to prepare a foundation; the greater number of them *fifty feet in length*, 9 feet deep, and 10 feet wide, "and some were bigger even than these." And Alberti relates, that, at a time when the Romans were averse to extravagance, and conducted all things frugally, Numa laid out 4000lbs. weight of silver in the foundation alone of one small temple.§

Knowing full well that a pointed staff will sooner penetrate the earth than

* I would not however be understood to say that *all* their buildings were constructed with equal care. Vitruvius once or twice complains of those who build in haste; and a comparison of the amazing number of Temples mentioned in the Itinerary of Pausanias with that of those remaining to us, will sufficiently prove how many there have been which passed away and left no sign.

† As translated by Sir Roger L'Estrange. ‡ 1 Kings vii. 10.

§ *Della Architettura Di Leon Battista Alberti, Da Giacomo Leoni.*—A more extensive genius than Leoni Alberti has perhaps seldom existed: he early outran all his contemporaries most noted for learning, and, possessing an intimate knowledge of all the Arts, was termed the Florentine Vitruvius. In perusing his works a smile is sometimes called forth by the gravity with which he acknowledges that he does not despise the advice of those who say, that all wise and prudent men, before building, will first by *augury* enquire what fortune will attend them; or by his reiteration of the astrologers, who affirmed that the spirits of those who *cut their nails* while the moon is unwell, will always be oppressed with melancholy; and other vagaries characteristic of his times; they are however replete with the most valuable information, and should be well studied—more especially the book appropriated to Architecture—by all who profess the art. He died 1485.

a blunted one, the ancients saw the problem was altered only in degree, when they inquired into the relative merits of large and small stones in the construction of foundations; they saw that the larger the stone, the more blunted was the end—the greater would be the proportionate resistance offered by the soil—and, therefore, that the nearer they could bring their foundations *to resemble one whole*, the more closely they approached perfection.

The use of piles of wood, driven into the ground, in order to bind up and connect, as it were, the loose or yielding soil, and thus to form a more solid bottom, appears to date from a very distant period. The brick pyramid in Egypt, built in a marsh by Asychis, son of Mycerinus, King of Egypt, so far back, according to the received chronology, as nearly 1100 years before the Christian æra, was placed upon a foundation thus prepared;* and Homer, who flourished, as may be inferred from Cicero and Strabo, probably about 1000 years before Christ, appears to have understood their use; for he says, when describing the destruction of the Grecian wall by the Gods, "The Earth-shaker himself, having a trident in his hands, led. And he destroyed with his waves all *the foundations formed of logs* and stones, which the Greeks had placed with labor; and he made it smooth along the swiftly flowing Hellespont." Or, as Pope has paraphrased the passage, [*book* xii. *line* 29.]

> "The God of Ocean marching stern before,
> With his huge trident wounds the trembling shore,
> Vast stones and *piles, from their foundation* heaves,
> And whelms the smoaky ruin in the waves."†

Descending a little lower, we find that the foundation for the (according to Pliny) magnificent and justly celebrated temple of Diana at Ephesus, raised under the direction of Chersiphron, 600 B. C., was formed by a stratum of pounded coals, into which piles were closely driven; the spaces between them were afterwards filled up with fleeces of wool and pounded charcoal, in order to form a surface.

The use of piles in the construction of foundations, then generally adopted, has continued to the present day, backed by the strong recommendations of Vitruvius, Palladio, Alberti, Scammozzi, &c. among the older authors, and re-urged by nearly every writer upon the subject in our own times; there

* Rollin says that upon this structure there was the following inscription, "Compare me not with pyramids built of stone, which I as much excel as Jupiter does all the other Gods," &c.

† In the same book, line 258 to 261, it may be considered that he again refers to them.

was however another method of preparing foundations made use of by the ancients, known as early, and of which there remains perhaps a much greater number of examples than of the former, but which certainly has not received a corresponding attention from those who have written of foundations. This consisted in the *concretion*, by means of mortar or cement, of broken flints or rubble on the site of the intended structure; whereby the great desideratum before alluded to, was in reality attained, as, from the mass thus formed, the foundation might be truly said *to consist of one solid stone*, and to this method—of which in its modern shape this Essay is intended to treat—I shall now direct and confine my attention.

It appears probable that trenches filled in with loose stones were the first step in this arrangement; and when afterwards, as an improvement, compacted into a solid mass by a calcareous or other cement for the same purpose, that rubble walls, which we find so generally used in all parts of the world, sometimes constructed of two faces of masonry filled in with stones, &c. rendered solid by mortar, and at others wholly formed by concretion, was an ultimate result. It will therefore be well for us, in tracing the history of this method of forming foundations, to pay some little attention to the use made of the same principle in the construction of walls, which, in all cases, has been alluded to, and sometimes recommended by various writers on the subject, while for the purpose in which the efficacy of the principle was probably first demonstrated, it has been nearly neglected or overlooked.

In Mexico, Mr. Bullock discovered, that many of the most ancient monuments of that country's former magnificence were raised upon artificial foundations, constructed sometimes wholly of pebbles or broken stones, and at others of broken stones and clay firmly compacted; he also found that one of the terraces appertaining to the remarkable pyramids of San Juan de Teotihuacan, was formed of a cement of pebbles and lime, which appeared to defy all time. There is however so much mystery with regard to the date of ancient Mexican architecture, that, although many of the instances seen by Mr. Bullock must be of extreme age, it is to Egypt we may perhaps more satisfactorily look for the earliest remaining examples of our subject.

We find there that many of the towns were originally raised upon *a rubble substruction*,* the periodical rising of the Nile compelling them to place all their edifices upon a sufficient elevation to preserve them from its effects. In

* Private information—see Sir William Drummond in confirmation. Archæologia.

their buildings too, it would appear from Quatremere de Quincy, they used a concreted rubble work, for he says, " Les anciens Egyptiens mêloient à leurs ciments des éclats de pierre, et de marbre. Ou en trouve beaucoup dans l'interieur du massif, et dans les arrachemens de la grande pyramide." *

In Greece, the foundations of all the very early fortifications were formed of small stones.† Some of the walls of the stronghold at the pass of Thermopylæ are constructed of small stones and mortar. Thucydides, describing the way in which the ancient walls surrounding the Acropolis had been restored after the first Persian war, about 478 years B. C., says the foundations consisted of stones of all forms and sizes thrown in indiscriminately; and the foundation which supports the central inclined plane of the Propylea at Athens, constructed not long afterwards, is also of rubble work. These still remain, and are so hard as to be almost impenetrable.‡

Vitruvius, who flourished in the first century of the Christian æra, when treating of the various methods of building used by the Romans, describes under the title of Εμπλεκτον, [Emplecton] walls constructed of two faces of masonry filled in with *cement*, which cement consisted of pounded bricks or tiles, rough stones, or flints, and lime, well incorporated; and he goes on to observe there are few places, which will not furnish materials with which may be constructed most strong and durable walls. This method of building was not so much used by the Greeks, who preferred solid stones; there are however examples at Pharsalia,§ and at the city of Messene, where in fact the walls surrounding the town, erected 370 years before our æra, are wholly of this description. At Rome it was every where used, the Temple of Augustus, the Baths of Agrippa, of Titus, and of Dioclesian; the Colliseum, the Aqueducts, St. Peter's, and many others, serving as instances.

I may perhaps here mention that the remarkable and well known wall of China, built about 205 B. C., was constructed in a somewhat similar manner, and notwithstanding numerous vicissitudes is still wondrously strong, discovering no signs of ruin. ‖

Walls formed wholly by concretion—without the intervention of solid facings—and which more closely approach our subject, were made, Alberti says, like the earthen walls of Spain and Africa, by placing planks on each side the intended thickness of the walls; between these were poured

* *Encyclopédie Methodique*—" *Egypte.*"

† A Treatise on the Arts, &c. of the Greeks and Romans.—Lardner's Cyclopædia.

‡ Stuart and Revett. § Stuart's Dictionary of Architecture.

‖ Barrows's Travels in China.

pebbles or broken stones and mortar, and there they were so retained until hardened to a mass. Palladio describes a like method, which he terms *Reimpiuta*, but says that for walls of cities they should be faced with bricks and filled in with *cæmentum*, brickbats, &c.—the emplecton in fact of Vitruvius.—" I muri di pietra cotta nelle muraglie della cittá; ò in altri molto grandi edificii si debbono fare, che nella parte di dentro, & in quella di fuori siano di quadrello, e nel mezzo pieni di cementi insieme col copo pesto."—*C.* 9, *Book* 1.*

In the aqueduct at Nismes, built by the Romans about the time of Augustus, the canal is composed of a sort of jointed rubble work, which, where the cement has not been spared, has formed an impenetrable mass.† Cisterns were rendered water-tight by a layer of this composition, and in many other of the aqueducts it forms a principal feature. Of the advice given by Palladio and others on the subject, we shall have occasion hereafter to speak.

All small stones, whether pebbles or flints, came under the denomination of *cæmentum*, the men who worked it being termed *cæmentarii;*‡ and so generally was it used, in fact so favorite a mode of construction did it become, from the astonishing solidity which it conferred, that there are few remaining Roman monuments in which, either in the foundations, in the shape of walls, of pavements, or of water-tight linings to tanks, &c., which endure remarkably well to this day, it may not be found. This appears to be the description of work termed by Vitruvius *signinum opus;*§ in this the cement used consisted, according to him, of 5 parts pure sand and 2 parts lime, with which, when well incorporated, they mixed pieces of stone weighing each about 1 pound. Pliny says, to make good cisterns the cement should be composed of 5 of fine sand and gravel to 2 of lime, the most ardent that can be obtained, and that none of the stones to be mixed with it should exceed one pound in weight. To increase its solidity, he says, it should be well beaten together.

The Roman roads were constructed upon the like principle of *concretion*, and are instances of the strength and durability of masses so formed.

With respect to the application of this principle in the preparation of

* *L'Architettura Di, A. Palladio, Da Giacomo Leoni.*

† Stuart's Dictionary of Architecture.

‡ Mr. Essex, on the Antiquity of Brick and Stone Buildings in England.—Archæologia, v. 4.

§ The term, it is supposed, was derived from Signia—an Italian town, where probably it was first used.

artificial foundations by the Romans, Vitruvius says, when they found the ground was tolerably solid they used any rough materials they could find near the spot; "sive silex, sive *cæmentum*, aut coctus later, sive crudus, his erit utendum." To construct walls in water, he says, sand should first be procured from that part of the coast about Baiæ, lying between Cumæ and the promontory of Minerva, and mixed with lime in the proportion of about 2 to 1. Rows of grooved piles must then be driven into the water, a sort of coffer-dam is formed with planks and bound with chains, and the bottom of the space comprehended between the piles and planks, being first made perfectly level, is to be filled with a composition consisting of *rough stones and cement made in the manner just described.* "Such is the quality of the sand, he continues, from these spots that the whole becomes a solid wall." *

And again, when describing the building of a mole, he says, the foundations are to be dug of greater width than the intended walls, and *filled in with rough stone, lime and sand;* he however directs that in all cases when the ground be soft, piles of charred wood should first be driven. He does not, I think, mention the application of the principle to buildings on land, although it was very generally adopted. In the sepulchre of the Antonini, says Alberti, the foundation was formed of broken pieces of very hard stone, none larger than could conveniently be held in the hand, completely drowned in mortar; † and similar foundations were met with at the Forum Argentarium and other places. Sometimes, he goes on to say, they formed the foundation with common gravel, pieces of chalk, &c., without mortar, as was seen when pulling down a high tower at Bologna; and all having endured so long, he was unable to pronounce which was the best, and therefore advised the cheapest method, care being taken that nothing likely to decay be thrown in. When the ground is unstable, following the steps of Vitruvius, he directs that it should first be piled.

To England the Romans brought their arts, and here practised them; accordingly we find, in the remains of the various buildings erected in this country during their occupation, specimens of nearly all their different modes of construction. At Richborough Castle in Kent many of the walls, which are of Roman workmanship, and are 12 or 13 feet thick, are of two facings of stone or brick, filled in with chalk rubble and flints grouted together. "The interior area," writes Mr. Britton, in his invaluable Chronological History of Christian Architecture in England, "may be divided in

* Vitruvius—translated by Wilkins. † *Della Architettura Di L. B. Alberti.*

imagination into the lower camp, where the tents of the soldiery were pitched, and the upper camp, containing the tents of the superior officers, the place for sacrifice, &c. In this lower camp [quoting Mr. King, *Monumenta Antiqua*] we find a most perfect and most extraordinary remain; for in this very spot, where we may be assured the prætorium stood, has been discovered, at the depth of a few feet below the present soil and rubbish, a solid regular platform, 144 ft. 6 in. in length and 104 ft. in breadth, being a most compact mass of masonry composed of *flint stones and strong coarse mortar*, with a coat of the same mortar spread over the whole, to reduce the surface in every part to a perfect level. In the centre of this platform is a second compact mass of masonry placed upon the former and made to rise almost 5 ft. above it; this Mr. King supposes to have been the foundation of the sacellum for the reception of the eagles, &c."

The foundations of the walls at the Roman station, Aldborough, Yorkshire—the upper parts of which are formed of round pebbles united by a strong cement—and of some portions of Severus' wall, consist of rough stone and pebbles compacted in clay; * while in several other instances we find they used perfect concreted masses of gravel, sand, or pounded bricks and lime, precisely similar to the *concrete* of our day.

When Sir Christopher Wren was about to rebuild the parochial church of St. Mary-le-Bow, Cheapside, after the fire of 1666, the ground, on which had stood one private house, was purchased for the site of the steeple, so that it might range with the houses in Cheapside. "Here, to his surprise, he sank about 18 feet deep through made ground, and then fancied he had reached the natural soil and hard gravel; but, upon examination, it appeared to be a Roman causeway of *rough stone*, close and well rammed, with Roman brick and rubbish at the bottom for a foundation and all *firmly cemented*," and upon this, which was 4 ft. thick, he concluded by laying the foundation of the tower, as most proper to bear what he had designed, a weighty and lofty structure.†

It is rather strange that Sir C. Wren did not resort to a like preparation under a portion of the Cathedral of St. Paul's, where it might have been employed with advantage, for we find that at the "northern point of the eastern boundary they came to a pit from which the pot-earth,—on a stratum of which, from 4 to 6 ft. deep, St. Paul's is built—had been removed and rubbish substituted. The length necessary for the completion of the foundation was not more than 6 or 7 feet, but, having *no opinion of*

* Mr. Essex, ut sup. † Memoirs of Sir Christopher Wren, by James Elmes.

piles, there remained no expedient but that of digging through the sand to a solid stratum, and building up from a depth of 40 feet," which was done.*

Perhaps the earliest description of the preparation of a foundation by the Anglo-Saxons, who, succeeding the Romans, imitated them to the extent of their ability, is of that of the monastery of Croyland in Lincolnshire, commenced in the early part of the eighth century. This building is said by the historian Ingulphus, as quoted by Mr. Britton in his chronological history before referred to, to have been of stone—taking the place of the wooden oratory of St. Guthlac—and as it was necessary, from the marshy nature of the soil, to form an artificial foundation, a vast number of piles was driven into the ground, and a solid surface formed upon them by earth and sand brought from a distance in boats.

The walls of Aldborough Church, Yorkshire; the tower of Earls Barton Church; that of St. Peter's Church at Barton upon Humber, Lincolnshire; and a building at Warmford, Southamptonshire—all of which, in the opinion of several antiquaries, are of Anglo-Saxon structure—are composed, some of round pebble stones united by mortar, and others of rubble stone and flints well grouted; they are still of amazing solidity and appear to defy time.

That they, in like manner, formed artificial *foundations* for their chief buildings by concretion is nearly certain; Sir C. Wren, when excavating for St. Paul's Cathedral, discovered that which led him to believe that the splendid pile, which previously occupied the site and was destroyed by the great fire, had been constructed upon the foundation of the old Anglo-Saxon building which preceded it. This foundation was composed of *a mass of Kentish rubble stone cemented with extremely hard mortar.*†

The Normans often constructed buildings *entirely* of rubble stone or pebbles, rendered into a mass by lime; nearly all their edifices have *some* parts so formed, and many of them have that description of foundation.

Salisbury Cathedral is built upon a rock thus formed,—truly worthy of admiration for its solidity, says an antiquary,‡—and at the Abbey Church of St. Albans, Ely, Peterborough, Chesterford, St. Giles's and St. Benedict's Cambridgeshire, concreted masses, for one purpose or another, are exhibited.

The foundation on which the north transept of Westminster Abbey is built, dating 1245, is composed of *flints, irregular stones, rubble and mortar,*

* Britton's Public Buildings of London. † Stuart's Dictionary of Architecture.
‡ Mr. Moule.

forming a body almost impenetrable;* and many of the buildings erected during two or three centuries after this period displayed, either in the walls or foundations, a like construction. I might cite the palace of the Bishop of Durham in the Strand; Savoy Palace; the earlier portions of St. James' Palace, and others.

The use of a concretion for the purposes of foundations has been long, and is now, well known and much used in France under the name of *Béton*. According to Belidor,† who strongly recommends its adoption, it is thus composed: "On forme, sur un terrein bien uni, et bien battu, une bórdure circulaire composée de douze parties de pozzolane, de terrasse de Hollande, ou de cendre de Tournai, sur laquelle on met six parties de sable, bien grené et non terreux, repandu egalement. On remplit l'interieur de ce cercle de neuf parties de chaux vive, bien cuite et concassée avec une masse de fer; afin, qu'elle s'eteigne plus vite, on y jette ensuite de l'eau (on doit prendre de l'eau de mer pour les ouvrages maritimes) et on y mêle, comme en faisant le mortier ordinaire, la terre qui sert de bordure. Lorsque le tout est bien mêlee on y jette treize parties de recoupes de pierre ou de cailloux, dont la grosseur ne doit pas surpasseur celle d'un œuf de poule. On remue a force de bras toute cette composition pendant une heure, et on en forme des tas qu'on laisse sécher pendant vingt-quatre heures en été, et durant trois ou quatre jours en hiver." Relative to the properties of this composition he relates, that Monsieur Milet de Monville filled a box with it, containing 27 cubic feet, and sank it in the sea; after remaining there two months it was taken out and found to be *harder than stone itself*. Quatrèmere de Quincy,‡ after describing the *signinum opus* mentioned by Vitruvius, says, "we clearly see, from this detail, that it was nothing more than what we now call *Béton*, and the Italians *Smalto*."

At the present time *Béton* is much used in Paris, and is usually composed of 2 parts sand to 1 part *hydraulique* lime, mixed with as much broken "*meuliere*"—a flinty sort of stone presenting very ragged forms when broken—and small pebbles, as can be well introduced without making it too dry. The stone from which the hydraulic lime is made—so termed from the property given by it to mortar, of *setting* and hardening under water—is procured from the quarries of Pantin; Buttes St. Chaumont;

* John Carter on the Ancient Architecture of England, 1795.

† *Architecture Hydraulique*, 1737. ‡ *Encyclopédie Methodique.*

Essonne, and Senange, but much is formed artificially by the mixture of fat clay, *Blanc de Meudon*, &c. with common lime.

The sewers, with which at this moment all the streets of Paris are about to be furnished—a measure long desired, and which must inevitably effect surprising and admirable changes in the domestic economy of the citizens—are invariably constructed upon a foundation of *Béton*, and the mortar, with which the walls are built, is made from the *hydraulique* lime.

A foundation constructed of *Béton* was used not long since for the bonding warehouse *Du Marais*, situated on the borders of the Canal St. Martin, with the greatest success; and at *L'Eglise de bonne Nouvelle sur le Boulevard*, where one half was built upon piles at an immense expense, and the other, including the belfry, upon *Béton*, its superiority, it is there said, has been proved beyond a doubt. In this digression, however, I have a little outrun my subject, and must therefore at once return.

Mr. George Semple, engineer, of Dublin, who published in 1776 a "Treatise on Building in Water," appears to be nearly the earliest modern English writer that treated of the construction of artificial foundations by concretion. He was at that time engaged in building Essex Bridge, Dublin, or rather in rebuilding it to another design, a bridge so called having been there many years, and when digging up the old foundations under the inner part of one of the frames on which the piers were builded, he found that the gravel, which in every other place had been soft and yielding, was so hard that no instrument would touch it, and he was compelled, in order to clear it away, to undermine and break it piece by piece with the hardest sledge-hammer that could be obtained. The middle of it, to use his own words, was an actual petrifaction.

This effect, he saw clearly, resulted from the *small quantities of lime the gravel had absorbed*, or which had been washed into it from the superincumbent masonry during a series of years; and the consideration of this fact, he says, of the *reimpiuta* of Palladio, and without doubt of that portion of Vitruvius relative to buildings in water before quoted, but which he does not, I think, mention, ultimately led him, after various experiments, to propound the construction of foundations by concretion.*

Speedily to make a cheap foundation for a statue in a basin, for example, he directs that a wooden coffer, strongly bolted, is to be placed in the proposed situation under the water, and filled with very small stones, clean and sharp sandy gravel, and Roach lime.

* From Belidor's "*Architecture Hydraulique*," just mentioned, he may also have derived some hints.

To form a foundation for the piers of bridges, he proposes to use a coffer filled with a similar *stuffing*—as he terms it in imitation of Alberti—and says, were he called upon to construct a turnpike road across a bog, he would build two rough stone walls to form the coffer, and fill in between them with a mass of flints or stones, clean sharp sandy gravel, and lime.

Of three different methods of making use of the lime in such work he writes at some length, and describes various experiments to determine the proper proportions of the several ingredients; these details however may perhaps be entered into with more effect under another head.

When Smeaton examined the ruins of Corf Castle, Purbeck, at a time when he was actively engaged collecting facts relative to the strength of materials, he found "that its solidity, as usual in ancient edifices, did not consist in having been built with large hewn stones throughout; for the filling in of the walls was of rough rubble and fragments from the quarries, the interstices being entirely filled up with mortar that had undoubtedly once been fluid, and in that state poured in; and from the nature of the component matter, as well as time, the whole mass had become strongly cemented together." The mortar was composed of lime, with a considerable admixture of sharp sand and pebbles.*

When he was about to construct the first lock on the River Calder, induced by the consideration of this circumstance,† he introduced what he terms a rubble backing, composed of 4 parts Barrow lime, 2 of coarse sand, 2 of fine sand, 2 of ground minion (siftings of the iron stone after calcination) and 8 of pebbles, the largest not exceeding in size a horse-bean; this was in 1760.‡

When the generic term concrete—derived, it is hardly necessary to say, from the Latin verb *concresco*, to grow together, to congeal, clot, or thicken—was first applied as a special appellation to the particular composition under consideration, can hardly be pointed out, the transition was so easy; but as this must have resulted from the general and frequent use of this concretion, the term perhaps can only date from that period when its use *became* general and frequent, probably not longer than 15 or 20

* A Narrative of the Building and description of the construction of Eddystone Lighthouse, by John Smeaton, 1793; a work which may be studied by all with advantage.

† See his Narrative, &c. *ut sup.*

‡ Smeaton's Backing, 1760.

Lime		Fine Sand		Coarse Sand		Minion		Pebbles		
4		2		2		2		8		
				or,						
22.22	+	11.11	+	11.11	+	11.11	+	44 45	=	109

years ago. It is true that in 1800 it was used by Mr. Ralph Walker at the East India Docks, but at that time it was so little understood that Mr. Rennie the elder, who was also engaged there, laughed at the idea, and when he found that Mr. Walker was in earnest, declared he would have nothing to do with the execution of it. Mr. Walker, however, persevered, and, notwithstanding the natural soil was exceedingly unequal and bad, in no one case did it disappoint his expectations.*

From that time to the year 1815 we find but a few isolated instances of its adoption;† in this year however, if I am rightly informed, it was used with success at the Penitentiary, Millbank. The soil was unstable in the greatest degree, and two towers, erected with some attention to this fact, entirely failed; they were taken down, having split in several directions, a body of concrete was introduced, upon which others were built, and they stand well to this time.

From that period to the present it has been more and more generally used; the very costly and—as has been too often fatally experienced—very fallible process of piling for foundations, has been nearly abandoned, and few, if any buildings of size or importance are now erected without the introduction of a concrete substratum.

That particular woods, if kept constantly dry or constantly wet, will usually remain perfectly sound for an astonishing number of years is quite certain; but it is also as certain that there are many causes which *may* operate in effecting their decomposition, hardly to be guarded against; and that if exposed in their natural state to the action of the atmosphere and water alternately, this MUST result.

This was strikingly exemplified at the Custom-House, the foundation of which, constructed of piles, failed within a few years after its erection, and on examining the piles many of them, it was found, were decayed. They were therefore removed, and the foundation reconstructed with a concrete substratum with the most complete success.

The theory of decomposition should perhaps be briefly illustrated, its intimate connection with the subject excusing the apparent digression. It may be done by one example. Hydrogen and oxygen gas, in certain proportions and under peculiar circumstances, from their affinity for each other—which

* Mr. Macintosh.

† A concrete of Kentish rag-stone and liquid mortar was placed between the heads of the piles on which Waterloo Bridge is built—1811.

The foundations for this bridge were formed by means of coffer dams, said to be the first instance of their use in the Thames.—Britton's London, *ut sup.*

affinity, or tendency to unite, is common to all bodies in various degrees—combine and form water; if, however, a third substance be introduced having a stronger affinity either for oxygen or hydrogen than they have for each other, the previous connection is destroyed, and a second compound formed; if, for example, into the water be thrown the metal potassium, which has an inordinate affinity for oxygen—much stronger than hydrogen for that, or that for hydrogen—this is the result, and the thus rendering a body back into its original elements, or causing other combinations for the purpose of destroying existing affinities, is termed decomposition.

On the earth nothing remains at rest; those elements which to-day, combined, form water, may to-morrow be as air—which last week assisted to nourish a plant, may this week be constituents of our own body.

> "All forms that perish other forms supply,
> By turns we catch the vital breath and die."

Now it may be taken as a general rule, that in all compounds the more numerous the ingredients, the less powerful is their affinity—the more easily may the body be decomposed—and, as the vegetable principle albumen, by means of which, it is believed, the decomposition of wood is commenced, is a compound of no less than four elements, nitrogen, oxygen, hydrogen, and carbon, we do not feel surprised when we find it to be a substance exceedingly disposed to change.*

The liability to decay, which we see thus entailed upon piles, is not, however, the only evil to be dreaded in their use; various accidents have at different times occurred from the sinking of some of the piles while the others have remained stationary, consequent on the unequal distribution of weight. To say that concrete, as used in foundations, is liable to none of these objections, that, so far from being by its nature perishable or liable to decomposition, each year but serves to increase its strength, and that the circumstances under which alone its decomposition could be effected, render it almost impossible that this can ever take place, is but to say that which the evidence of centuries has already abundantly proved; I must not at this point, however, dilate longer upon its excellence, but proceed at once to consider the various methods of composing concrete, and some of the more important details connected with its use.

The concrete now generally employed is compounded of Thames ballast and Dorking lime, in certain proportions; varying, according to the opinion of the user and goodness of the materials, from 1 of lime and 4 of ballast to

* Dr. Birkbeck.

1 of lime and 12 of ballast. They are sometimes mixed together, slaked as mortar, and thrown into the foundation from a certain height; sometimes the ballast is laid on the site of the intended erection, and the lime poured over it in the shape of grout; while at other times the spaces to be concreted are filled with water, and the lime and ballast, having been first mixed in the proper proportions, are thrown into it dry. Instead of gravel, Kentish rubble and broken pieces of granite, properly grouted, have been extensively employed, more especially by Sir John Soane, who has used a preparation of this sort for most of the public buildings in Westminster executed under his direction; viz. at the Law Courts, the additional buildings to the House of Lords, the Library of the House of Commons, the Board of Trade and Privy Council Offices, the State Paper Office, and others. The foundations for these edifices were formed of granite, or other hard stone, broken in small pieces (none exceeding the size of an ordinary hen's egg) and laid in layers closely rammed, and grouted every third layer with a grout composed of Dorking lime and sharp river sand: other layers of similar pieces of stone were then laid, and rammed and grouted as before, and so the operation was repeated until the required thickness was attained. Upon the top of the mass thus formed there is usually a tier of York landings, connected by a chain-bar, from which arise the walls; and in some instances, as at the State Paper Office, the brickwork having been carried up to a certain height, a second tier of landings was introduced.

At this latter building, the natural foundation being excessively bad (for it was at one time, without doubt, the bed of the river), they were obliged to excavate twenty-two feet through peat, and, when this was taken out, could hardly keep the bottom sufficiently free from water by the pumps for the men to work. In consequence of this and other circumstances, the concretion or rather the macadamisation (as this method has been termed) was executed at great disadvantage,* but from the use of the landings and the excellence of the brickwork the building appears to stand well.

Notwithstanding the high, and deservedly high, authority of Sir John Soane's name, to me there seem several objections to the general adoption of this method. In the first place, from an examination, I find that into many of the interstices, unless the work is executed with greater care than can in

* In some parts too, in consequence of the sand and loose gravel being pumped out with the water, holes of some size were formed at the bottom, producing inequality of surface; these were filled up to the general level, by throwing in larger pieces of stone than those ordinarily used, mixed with lime and sand, and a concrete prepared as above was then put in to produce the required thickness.

all cases be insured, necessarily occurring between the stones, and which are many more than can possibly exist when the stones used are of a variety of sizes, intimately mixed as in ballast, the grouting does not penetrate; whereby the solidity of the mass is materially interfered with; secondly, by the after-ramming much injury accrues to the lower stratum, by that time perfectly *set;* and thirdly, notwithstanding these two disadvantages—and although perhaps they may be termed by some, slight in practice, they really *are* disadvantages—the expense of a foundation thus prepared is considerably more, under ordinary circumstances, than when a concrete of ballast and lime be used: granite, too, being a compound substance, and one, notwithstanding its proverbial strength, liable under certain circumstances to disintegrate, while flint or gravel, for it is the same thing, is nearly elementary, the *possibility* of decay, although remote, is increased; so that although no one can doubt but that a most strong and durable foundation may be thus formed, I should, from a consideration of the foregoing objections and a due examination of a foundation so constructed, compared with another for which ballast was used, select the latter as preferable even were the expense the same. The adoption of this method by Sir John Soane appears to have resulted from this circumstance, that many of the before mentioned buildings were erected by him on the site of previous constructions; the old foundations of which, mostly of granite and Kentish rag, he could in no way so well get rid of, as by breaking up for this purpose, while at the same time he lessened the cost of his concrete.*

I return to the former mention made of the concrete most generally used, which offers two points for consideration; first, the proportion of the various ingredients; and secondly, the methods of mixing and applying them.

In order properly to apportion the quantity of lime necessary to be used with the ballast, it will be well that you ask yourself this question,—what are you, in reality, doing, when forming a mass of concrete? or rather what *ought* to be done? To this the answer must be, that you are building a stone wall; in a manner, it is true, possessing advantages entirely its own, but still a stone wall. The pebbles, then, are *the materials with which it is to be built*, and must be regarded only in that light, so that in considering the quantity of lime necessary to be added, in order to form a *proper mortar* wherewith to unite them, regard must alone be had to the sand contained

* If the broken granite, &c. be mixed with proper proportions of lime, sand, and water, and thrown into the foundation as when ballast is used, it is clear a most admirable concrete will be formed; but much greater expense is incurred, and there is certainly no corresponding advantage.

in the ballast, and according to the quantity and quality of that ingredient must be apportioned the lime. It is true, that upon the proportion borne by the pebbles to the mortar, the strength and goodness of the concrete materially depend, but this, except under peculiar circumstances, must but little interfere with the preparation of the mortar; it is another question, separately to be considered.

Now, practice and a variety of experiments have shown, that Dorking stone lime, being ordinarily good, will form a most excellent mortar when mixed with three times its own quantity, by measure, of sand; and, although it is quite certain that if it be well burned, ground, and used hot—and thus it *must always be* for concrete—it will make excellent mortar when mixed with four of sand,* even better, if the lime be powerful, than with less, this may serve us as a generally admitted good proportion.†

With respect to the amount of stones essential to a good concrete, it is generally maintained by those practical men who have thought upon the subject—unfortunately but few—that it should be double that of the sand by measure, and my own experience fully bears out this belief. Three masses of concrete, equal in bulk, were formed in pits prepared for them; No. 1 was compounded of screened stones, well grouted with lime water, no sand or small stone was present; No. 2 of four parts stone and one of sand; No. 3 of two parts sand and one of stones; and No. 4‡ two parts stones to one of sand, the lime in these three cases being the same, viz. one-third the quantity of sand, (as above premised) and properly mixed with water. When sufficiently indurated, a sharpened pole was, by means of a lever, forced down into them with a certain calculable force, and the comparative degree of resistance offered to its entrance, was in the reverse order of the numbers. Various other experiments were tried, making alterations in the proportions of the ingredients, but in all cases it was clearly shown that *two parts of stones and one of sand, with sufficient lime—dependant on the*

* It was usually thus compounded by the late John Nash, Esq.

† Vitruvius says the Romans used 3 parts of sand to 1 of lime, but Pliny says 4 to 1; there is little doubt but that their opinions were as various as are ours.

Dr. Higgins recommends 1 of lime *by weight* to 8 of sand in his treatise on calcareous cements, 1780.

‡ First Experiment, Mass No. 4.

Stone	2 parts	or say	6.
Sand	1 ,,		3.
Lime	$\frac{1}{3}$,,		1.

or in 100 parts.

Stone 60. Sand 30. Lime 10.

quality of the materials—to make good mortar with the latter, formed the best concrete.

To say that concrete compounded entirely and merely of large screened stones and lime, cannot be comparable to that in which sand is present, appears almost supererogatory without the evidence of experiment; as however it has been so used by some intelligent men, and, in consequence, probably will be again by those who think more of precedent than principle, it may be well to remark, that when the mass No. 1 was removed from the pit in which it had been made, and submitted to a crushing pressure, unsupported by the earth as in the former instance, it was found to possess the greatest friability, and, as compared with the others, to offer *no* resistance, much less even, comparatively, than in its first situation. I may add in confirmation, that the North wing of the new palace in St. James's park was at first erected upon a bed of concrete thus prepared, and that this never became a mass, as was discovered some time after when it was taken up in consequence of alterations.

In the formation of concrete, solidity is the great end to be attained. We know very well that although a pit appear filled with large stones, the interstices, necessarily occurring, would still admit a great quantity of smaller stones, and that, even then, sand to a large amount might be introduced without occupying more space. Variety of size in the stones employed, and consequent need of sand, is therefore of importance even in this point of view, to say nothing of the necessity for its presence in the formation of mortar whereby the stones are to be connected. No effect will be produced by lime alone; it is from its mixture with sand that the properties of mortar result, and, as every practical man knows, it is much better that it have too much of this ingredient than too little.

Semple, in his work already quoted,* which really appears, with some few exceptions, to have left the subject where it now is, shows, when detailing the method he adopted to prove what were the best proportions, that he had attended to this principle of solidity; he says "I had a box formed, containing one exact cubic foot, which held 200 stones fit for the purpose, each stone weighing, on an average, 7 or 8 ozs., the whole consequently weighing 90 lbs. nearly; the same box held 80 lbs. of tolerably dry, sharp, and rather fine sandy gravel, without any sorts of stones except those small ones usually among sand. Part of the stones I put again into the box in thin layers, filling in all the interstices with the sand,

* "A Treatise on Building in Water," &c. 1776.

and after that manner it contained 80 lbs. of the stones and 40 of the sand, and I know it would also have held the proportionable complement of Roach lime, that is, 10 lbs. made liquid; this together gives the just quantities and proportions of 10, 40, and 80, or 1, 4, and 8, which will be much easier remembered and must be strictly observed; hence also please to notice, one cubical foot of this stuffing will weigh 130 lbs., which is nearly the same as Portland stone."*

In the mass No. 4, offering the greatest resistance in our first experiment, the proportions would appear thus: lime one part, sand three parts, and stones six parts, by measure—*lime forming one-tenth only of the whole mass*, and this it has been proved is quite sufficient, nay better than more, provided the proportions of sand and stones are maintained.

Now it is found that Thames ballast of the best sort, as it is taken from the bed of the river, averages a mixture of these two ingredients, nearly approximating to that which I have supposed to be the best, viz. 1 of sand and 2 of stones; it is therefore ordinarily used in its natural state, much trouble and expense being thereby saved; but as the amount of stones is usually less than double that of the sand, and since when measured as ballast a greater quantity of the sand and stones is contained than would be the case if apportioned separately, as hereafter will be shown, it is deemed that the quantity of lime, to form a just proportion with Thames ballast, should be one-eighth, or even one-seventh of the mass. Again however I would say, something must be left, in this respect, to the judgment of the architect: the strength of the lime employed must be considered, and the quantity of sand contained in the ballast, more than the just proportion, ascertained by examination, for on these and these alone, as before stated, depends the quantity of lime necessary. Too much lime is as prejudicial as too little, to say nothing of the increased expense, and the reason is obvious, for a wall built of *sand*, i. e. flint—solidified by lime, (and this in all cases is its only purpose) must be much better than one constructed of lime alone, which is of itself of a friable nature, and unequal to afford support; and this would of course apply to a wall of stones, the interstices in which are to be so filled up.

With regard to this excess, it has been observed that if, when the concrete is thrown in, lime be floated to the top by the water, and form there a sort

* With respect to the proportions here stated I say nothing, as it is almost impossible *exactly* to determine quantities of lime and sand by *weight*—so many things may interfere to vary it—those above mentioned would perhaps form, by measure, 1 of lime to 2 of sand and 4 of stones; but the circumstance is quoted merely as a farther illustration of the solidity gained by the variety of size in the materials.

of putty, it is certain that more is present than is required by the sand, as this phenomenon never occurs under other circumstances.*

Of Thames ballast there are two varieties, which may be distinguished as the red and the black.

The red may be procured in great abundance on the Surrey side of the river, from Westminster Bridge to Hammersmith, the coarsest gravel lying nearest the shore. Of three loads of this ballast, measured and screened, the following are the results, its quality however of course varies according to situation, &c.

	BUSHELS.			
No. 1 contained, when separated	32 stones 19 sand	=	51 bushels.
No. 2	34 stones 23 sand	=	57 bushels.
No. 3	40 stones 20 sand	=	60 bushels.†

The average contents of a load were therefore fifty-six bushels, of which the proper proportion of sand should be about 18⅔ bushels, but the average of the above amounts to 20⅔ bushels. To use this therefore, an additional quantity of lime would be demanded, and the composition even then be inferior.

In the black ballast, which is found plentifully between Westminster Bridge and London Bridge, where, I am told, there is a bed of it nine feet deep; the amount of stones contained is *nearly* double that of the sand.‡ As it requires more fuel and labor to obtain this than the red, the cost is greater, but the proportions of its ingredients being those deemed the best, and its superiority as a material, in other respects, great, it should always be employed for the purpose of concrete when it can possibly be obtained. All stones larger than a hen's egg should be broken.

* James Savage, Esq.

† Thames Ballast.

RED.

	STONE.		SAND.		TOTAL.
No. 1	32 bushels	+	19 bushels	=	51 bushels.
No. 2	34 „	+	23 „	=	57 „
No. 3	40 „	+	20 „	=	60 „
	3) 106		3) 62		3) 168
Average . . .	35⅓	+	20⅔	=	56
Or	63	+	37	=	100

‡ BLACK.

	66.6	+	33.4	=	100

It is hardly necessary to observe, that if pit gravel be used, it should be well washed, in order to free it from all dirt or impurities, and a due quantity of clean sharp river sand, if needed, be added to it, care being taken that the stones are as various in size as possible, in order to attain a perfectly solid mass.

The proportions I have stated, namely one of lime to seven of ballast, are those which have been, and are now generally employed at the various buildings in and about the metropolis, and may always be applied with confidence under ordinary circumstances. I may perhaps mention that the concrete used by Mr. Telford at the St. Katharine's New Docks, by Mr. Inwood at the Westminster Hospital, by Mr. Savage at the Inner Temple, &c. was so compounded. At the Westminster New Bridewell, erected under Rob. Abrahams, Esq., where perhaps more concrete has been employed than at any other building in London, £30,000. having been spent in the foundations, the opinion of all men scientific on this point were sought, and experiments were tried from the beginning to the ending of the works, in order to improve, if possible, upon the concrete last used; there being, as is well known, a variety of buildings on the ground, most of which were commenced at different periods. Here each experiment served to prove, that the proportions originally set forth by the architect in his specification, viz. one of lime to eight of ballast,*—and in which, that of lime is seen to be smaller than in those just recommended,—applied according to the first method to be described, formed a most perfect concretion. These were accordingly used throughout the works, and, notwithstanding they were many feet below the high-tide-level, that the whole foundation was in fact under water, neither in the boundary walls, nor in the mass of buildings constituting the prison, is there the slightest settlement. The thickness of the concrete substratum is above seven feet.

Through the kindness of Mr. Abrahams, and for which I take this opportunity to offer my thanks, I am enabled to append a copy of such portions of the specification for building the prison as relate more especially to the artificial foundation; which, having been found perfectly comprehensive, and sufficiently binding for the purpose, must be esteemed valuable *as a precedent for specifications* in which similar arrangements are to be made. [Appendix A.]

Mr. Ranger, who within the last few years has made concrete his peculiar

* New Bridewell.—Abrahams.

Lime.		Ballast.		
1	to	8	=	$\frac{1}{9}$th. of the mass.

study, generally uses, as I am informed, one of lime to six of ballast, thinking that the superior mixture.

In the Royal Dock Yard, Woolwich, there is an engine-house which is built upon a mass of concrete thus compounded. It is situated in a hole, and the concrete was placed upon the natural chalk without any digging, and formed into the present square shape by means of *caissons*, which were removed when it had become hard. The ground in some parts has been filled in to it, but, generally speaking, the body of concrete is *perfectly independent of extraneous support*. The engine-house upon it is constructed with very thick walls, and has a high shaft, or chimney, of great size, so that, adding the weight of the engine and other machinery within, there must be a pressure upon the concrete of at least 500 tons, without regard to the great and constant jar caused by the working of the engine; a more severe test could hardly be applied, and yet not the slightest flaw or settlement has taken place. Although the result clearly shows that the additional quantity of lime was not prejudicial, it appears to me, after an examination, that with the proportions before stated, a mass of equal excellence might have been formed.*

The methods of mixing and applying concrete are several, having each its advocates and opponents; the one most generally employed, and, as I shall attempt to show, the best, is, thoroughly to mix the lime, previously ground, with the ballast, in a dry state; sufficient water being then thrown over it to effect a perfect mixture, it should be turned over at least twice with shovels—if oftener, so much the better—put into barrows and wheeled away for use *instantly*. It is generally found advisable to employ two sets of men to perform this operation, say three in each set; one man to be engaged fetching the water, &c., while the other two turn it over to the second set, and they, repeating the process, turn it over to the barrow-men. Sometimes, instead of mixing the materials in a dry state, the ballast is spread out and wetted with water, then covered with the proper proportion of ground lime, and turned over as before.

After being put into the barrows, it should at once be wheeled up planks, so constructed as to gain a fall of some yards, and thrown into the

* It may not be uninteresting to mention here, that some time ago at the Arsenal, Woolwich, a battery was constructed upon concrete, by way of experiment, and that a ball having been fired into it, the resistance it met with in its descent was so great as to astonish those present, and call forth a letter from the officers on the subject.

foundation, which has the mechanical effect of driving the particles closer together and giving greater solidity to the whole mass. Soon after being thrown in, the mixture is observed to be in commotion, and much heat is evolved, sufficient indeed to throw off a large quantity of water in the shape of vapour. This is caused by what is termed the slaking of the lime. When water is thrown upon lime, the two combine, in the proportion of three parts of lime to one of water, and the result is *hydrate* of lime, or, in common parlance, slaked lime. In combining, condensation is effected—the lime and water together occupying little more space than the lime had before done singly. Now when the particles of matter composing a body be brought closer together, or the interstices, and these occur in all bodies, be filled up with other matter, as by mechanical compression, or chemical combination, it is supposed that its capacity for heat is lessened, for caloric is always evolved, as instanced in the above.*

During this process of slaking, the mixture slightly *expands*, and by so doing, forces itself together and still farther assists the consolidation. This effect is one of the advantages derived from the use of ground lime, independently of its being more powerful as a cement than when previously slaked—of this, however, hereafter.

The concrete, then, being thrown into the trenches, or intended site of building, it is customary with some to keep a man constantly employed in levelling and puddling it, as it is termed; this, if it be done, should follow instantly that the barrow load be emptied; for if the concrete be first allowed to set, much harm will be done by disturbing it, while the benefit which results in any case from the process is but trifling. For my own part, and it is also the opinion of many practical men, I would not have it in the least disturbed, but allow it to remain precisely in the situation into which it had been thrown from the barrows. As the concrete stratum approaches the surface this operation may in a degree be necessary, in order to obtain a level face, but whenever it is done, again I would say, let it be done quickly.

The barrow-load of concrete, in the fall, spreading over the ground, will

* The *rationale* of the condensation effected in the combination of two substances, may be understood by reference to the box of stones before mentioned; in which, although *filled* with large pieces, there was yet room in the interstices for many smaller ones: so it must be with bodies, between the particles of which, spaces, although for the most part invisible to us, without doubt exist, and into these a more subtle body will enter. The mixture of sulphuric acid with water offers a striking example; in this so great a condensation takes place that ½ a pint of each separately will not form together more than ¾ths of a pint, and so great is the heat evolved, that water, enclosed in a bottle and placed within the mixture, will boil.

be found, if continued regularly over the surface, to form a stratum from 7 to 10 inches thick, which should be allowed to set before throwing in a second; this, however, if the building be of any size, has usually taken place at the near end by the time that the far one is completed.

It is advisable always to perfect one stratum before commencing the second; but if this be impracticable, the second stratum or bed, as it approaches the end of the first, should stop something short of it; the third, in like manner, short of the second, and so to the top, forming steps, as it were, upon which the strata, afterwards to be filled in, may rest.

A second method of mixing the constituents and applying concrete is, after having dug to a good bottom, to pump into the foundation a certain quantity of water, say one foot in depth, into which ballast and lime, previously mixed in a dry state, are thrown from a height as before, until the whole be absorbed; it is then turned and levelled by shovels, more water is pumped in and the operation repeated. Mr. Macintosh, who has been engaged for several years in the preparation of concrete, has employed this method in forming the foundations for the viaduct of the Greenwich Railway. Under some of the piers they were compelled to excavate to a depth of eighteen feet, through a peat moss almost fluid, and this void was afterwards filled up with concrete thus mixed, which has answered the purpose, he says, admirably well. (The proportions were those I at first pointed out, as the best—one of lime, three of sand, and six of stones.*) There are, it appears to me, several objections to this plan; the most considerable one being the difficulty of effecting, under the circumstances, a perfect mixture of the ingredients—of the utmost importance as I have before said—having several times, upon examining a bed thus prepared, found many *parts to which the water had not penetrated.* Again; as the induration of mortar, under ordinary circumstances, depends on and is effected by the absorption of carbonic acid gas from the atmosphere, it should follow that, to bring this speedily about, each stratum must be in its turn for some time in *contact* with that atmosphere, and as by this last method this time is materially shortened—the concrete being for the greatest period under water—it must occupy, it is conceived, much longer when completed, perfectly to

* Greenwich Railway.—Macintosh.

		3 sand and 6 stone.		
Lime.		Ballast.		
1	to	9	=	$\frac{1}{10}^{th}$. of mass.

harden, than when thrown into the trenches according to the first method.* In large foundations too, it would be almost impossible to retain the water as required, and even with trenches in some soils it would be difficult; should the trenches or space to be occupied by the foundation, however, become filled with rain, this method might be resorted to and a saving of labour effected; or even were they, from the nature of the soil, under water, it might be adopted, and, with good lime and some care, an excellent foundation constructed, but as a general method I believe it to be inferior to the former.†

It is, perhaps, right to state that the advocates of this plan have the authority of Semple with them, for he says, "And herein lies the grand advantage that will attend all these projects, viz., they can be executed in water, and if we supply the water with due proportions of this stuffing judiciously, it will take great part of the trouble from us, and will, as it were, dispose of every particle of the finest sand, and, with incredible expedition, carry it into such interstices and small pores as it will find fit to receive it."

A third method, which is sometimes adopted, but appears to me from observation and experiment to have nothing to recommend it, is, to lay the ballast and lime in thin layers alternately, quite dry, and in this situation to throw water upon it; when, however, it is remembered how much the excellence of *mortar* depends upon the proper mixing and kneading of the materials, the imperfect nature of this plan must at once be visible.

At the New Bridewell, where, as has been said, a variety of experiments were tried relative to the formation of concrete, both with respect to the proportions of the several materials and the best manner of applying them,

* The amount of carbonic acid gas contained in the atmosphere is probably not more than one in 1000.—Thomson's Elements of Chemistry.

† It is in the adaptation of measures to circumstances that a man of science displays his ingenuity and resources. The assertion of Vitruvius that "an Architect should know every thing" was at one time fancied hyperbole, but he said little more than is absolutely necessary if the architect would attain any excellence in his most arduous profession. It is not the power of making a pretty drawing, or even of forming an elegant combination of parts, *alone*, that will now entitle any to the appellation of Architect; a knowledge of Mechanics, Hydrostatics, Chemistry, Geology, and all the other sciences, together with the power of clearly expressing his opinions both by words and in writing, and an acquaintance with the world and all its wants and wishes, are indispensable requisites to the formation of an architect. The Institute of British Architects, when, in their first address, they stated their intention to assist the student in the acquirement of this general information—an intention which has been already acted on in their proceedings—showed at once their idea of its importance, and the proper and enlightened views with which such an Institute should be conducted.

Mr. Butler, the clerk of the works, essayed a fourth method. Having by him the before mentioned quantities, viz., one part lime, three of sand, and six of stones, in separate portions, he made the sand and lime into common mortar and spread alternately a layer of this and a layer of stones, as if building. When, however, he had used all the mortar, he found that, although if these quantities had been mixed they would have formed a mass of excellent concrete—as we have before seen—there was by this method a large portion of the stones remaining unused, showing clearly this was neither a good or economical way of making concrete, as much extra expense was entailed by screening the ballast, without mentioning the additional quantity of lime required to form a certain mass, and that after all, from that very circumstance, the mixture was inferior in quality.

All their experiments tended to prove that the first method, as detailed, effected the most perfect combination of the materials, and was therefore decidedly the best.

In some cases it has been found advisable, in mixing the ingredients, to employ a sort of pug mill, worked by a horse, instead of manual labour, and, where a great quantity of concrete is to be used, this must be a cheaper method; it would be essential, however, in this arrangement justly to apportion the time occupied in the passage of the materials through the mill, as in all cases, for reasons before mentioned, the concrete should be thrown into the foundation *hot*.

Before quitting this portion of the subject, the power of improving a tolerably good foundation by partial concretion, at a comparatively trifling expense, may be mentioned. In a gravelly foundation it sometimes happens that the soil, although not sufficiently compact safely to build on, is yet hardly bad enough to call for its removal and the substitution of concrete, or if the foundation be even worse, that limited means may prevent the called-for outlay; in such cases, well and judiciously to grout the natural soil with lime and sand (or, should there be a sufficiency of the latter in the soil, with lime water alone,) would prove advantageous. I was led to this not merely by the fact narrated by Semple, and before quoted, namely the change which had taken place in the gravel on which stood the piers of Essex Bridge by its absorption of lime, but by a circumstance which, a short time past, occurred near the bridge built by Mr. Cubitt over the Grosvenor canal. When forming the foundation for this bridge, which is of concrete, there being rather more lime employed than was needed by the sand, some of it was floated away over the planks placed to retain it, and was deposited on the low grounds in the neighbourhood; which grounds, having been filled

up some time afterwards, became occupied as business yards. On attempting, in one of them, to sink a well, the stratum of soil penetrated by this lime was met with, and such a perfect rock had it become that they were compelled, with great labor, to break it into small pieces and so remove it. After a certain distance this effect disappeared.

Regarding the quantity of water that should be employed in forming concrete—the degree of fluidity which should be imparted to it—there exists a great difference of opinion, some contending for one extreme, and some for the other. The great degree of strength, exhibited by the Roman rubble walls, is ascribed by some authors to the use of mortar of an ordinary, or even extraordinary consistence, and they point in confirmation to sundry places where the mortar may be seen squeezed, as it were, into various interstices only a part of the way; while a second set contend this same strength arises from the *fluidity* of the mortar used; which is clearly proved, as *they* say, by the uniform mass shown in cutting into some of these aforesaid walls. That both these methods may have been pursued there is perhaps as little doubt, as that the strength of the walls depended entirely upon neither; nothing is so essential to the excellence of mortar as the due admixture and well kneading together of its constituents, and to the care exercised by the ancients in this particular may be chiefly ascribed the durability of their works. Smeaton proved by experiment, and this I have since repeated, that mortar will become extremely hard even if rendered to perfect fluidity,* but this experiment also showed that much time must first elapse. In the preparation of a concrete foundation, it is usually desirable to effect its induration as speedily as possible, and therefore it appears clear that more water than is absolutely necessary to bring about a perfect admixture of the ingredients, is not merely unnecessary but prejudicial, so—said one who wrote upon the subject—"let elbow-grease supply its place."

When it is desirable that concrete should set *immediately*—supposing for example that water can be kept from it only a certain time—the use of *hot* water in forming the mixture is found advantageous. Mr. Ranger always employs it, but, excepting for the purpose above mentioned, I do not consider it expedient; it is necessary to fit up a boiler upon the premises, and the expense is of course increased; to show the rapidity, however, with which concrete so compounded sets, it may be sufficient to state, that if in molding Mr. Ranger's patent stone—which appears to be nothing more than a mass of concrete faced up with lime and sand—two moulds be used, by

* See his Narrative, &c. *ut sup.*

the time the man employed has completed the second casting, the first is usually sufficiently hard to be turned out, in order that the mould may be again filled.

Having thus, as succinctly as was consistent with the subject, spoken of the various methods of forming the artificial substratum termed *Concrete*, I must say a few words upon one or two of the peculiarities developed in its formation, and which have been slightly touched upon before; and first, of the change in bulk which takes place in the ingredients when mixed together. Before it had been observed, that *a cube yard of ballast, with the due proportion of lime and water added, would not make a cube yard of concrete*—and this was but a short time since—many contractors suffered great losses from miscalculation, it is therefore important that this fact be properly understood. The *rationale* of the condensation brought about by the admixture of the ingredients has been already explained, I have therefore only to afford some data relative to the exact diminution in bulk, in order to a correct calculation, to complete this point.

Twenty-seven cubical feet of Thames gravel, measured with care, and 3 feet cube of ground lime were formed into concrete with 25 gallons of water—say 4 feet cube—and the mass resulting contained exactly 24 feet cube, and no more, so that the ballast and lime had lost $\frac{1}{5}^{th}$ in bulk by the admixture, without regard to the water.*

Thirteen feet 6 *inches* cube of ballast—which, being screened, was found to contain 10 feet 6 inches cube of stones and 3 feet 9 inches cube of sand, making together *fourteen feet* 3 *inches*—were well mixed with 1 foot 11 inches cube of ground lime and about 14 gallons of water. The concrete formed contained *twelve feet* 9 *inches* cube, showing a diminution in the materials (regarded as *ballast* and lime) of nearly $\frac{1}{5}^{th}$ as before, independently of the entire loss of the water.

Again, to form 9 feet cube of the patent stone—which, as I have said, is but concrete molded to the desired shape, and faced with lime and sand—it required 10 feet cube of gravel and about 1 foot 5 inches cube of ground lime, (that being the proportion used) which also shows a diminution closely approximating to $\frac{1}{5}^{th}$ of the materials.† To form a cubical yard of concrete,

* Mr. Butler.

† Diminution of original bulk.

BALLAST. cubic ft.	in.	GROUND LIME. cubic ft.	in.	WATER.		ORIGINAL BULK. cubic ft.	in.	WHEN MIXED. cubic ft.	in.
27	0	3	0	,,	=	30	0	24	0
13	6	1	11	,,	=	15	5	12	9
10	0	1	5	,,	=	11	5	9	0

showing the loss to be about $\frac{1}{5}$th.

therefore, we may say, it requires—the proportion of lime to be used being one-eighth of the quantity of ballast—about 30 *feet cube of ballast* and $3\frac{3}{4}$ *feet cube of ground lime*, with a sufficient quantity of water to effect the admixture. The price of the various materials then being known, and the amount of labour required, adding cartage, &c. according to situation, a calculation of its cost may easily be made.

Of the expansion which takes place in concrete during the slaking of the lime—a reaction as it were, upon the last mentioned phenomenon—and of which I have now to speak, an important use has been made in the underpinning of walls. The amount of expansion has been found, by experiment, to be about $\frac{3}{8}^{\text{ths}}$ of an inch in every foot of height; and the size thus gained, the concrete never loses, so that if it be placed in the desired situation before *heating*, as it is termed, this property will cause it firmly to wedge up and support the superincumbent mass. All due allowance or preparation should be first made to prevent accident, for, so great is the force with which this expansion takes place, that one, who has been long practically engaged in the application of concrete, assures me, he has seen a wall riven by it.

If the building to be erected is but small, it will be found sufficient, usually, to form a foundation for the walls, in trenches from 1 foot to 2 feet wider, or more as it may be, on each side, than their intended thickness, and in this case it will be well to remove the ground until a tolerably firm and equable bottom be found. When the building is large, or the natural soil bad, the whole of the space to be occupied should be dug out and replaced with concrete, and when this is the case, although of course it will be better to obtain a good natural bottom on which to place the concrete, if possible, it may, if unattainable, be used without; merely removing the soil to a convenient depth, and carefully *levelling* the bottom before filling it in.

An instance of its use under these circumstances, which came immediately beneath my own observation, may not be out of place. It was found desirable to erect a dwelling in the marshes near Ware, Hertfordshire, where the soil was of a nature so bad, so merely a bog, that piles could be driven in to any distance without finding a solid bottom; it was therefore resolved, in order to avoid fractures, to adopt the method, common in that neighbourhood, of building the house upon planks laid on the ground, under the impression that all would go down together. This was accordingly done, but

the house being of some extent it was hardly possible to maintain an uniform pressure upon all parts of the foundation, and, in consequence, the building split in various directions, and was ultimately taken down as unsafe. The necessity, however, for the erection remained, and, after some deliberation as to what could be done, it was determined to form for it a concrete substratum; an excavation was therefore made about 6 feet wider on all sides than the intended base of the house, which was about 40 feet square, and to a depth of 7 feet; farther than which they could not descend, on account of the water. Into this, and upon a bottom into which, as I have said, a pile could be driven almost to any distance without meeting resistance, a concrete, compounded of stone lime, and ballast from the river Lea, (or as it is there termed, silt,) was thrown from a height in layers, 6 inches thick, according to the first method described, each succeeding bed decreasing in size to the top, where the concrete was little wider than the walls. The amount of lime used, in consequence of the nature of the ballast, and other circumstances, was $\frac{1}{6}^{\text{th}}$ the quantity of that material. One month was allowed to elapse so that the mass might become tolerably solid, and then upon it was erected the house. It has now been there more than three years, and not only is it without the slightest settlement in the walls, or division between them and the thin lathed partitions dividing the interior, but the whole body remains precisely as much above the ground at this time as when first constructed, the concrete substratum having served, as Alberti says, speaking of foundations generally,—like a wide shoe does to those who walk upon the snow.

When it is necessary to use a lime concrete *under water*, as for the piers of a bridge, &c., it will be found essential, under ordinary circumstances, to remove the water in the first instance by pumps, and to allow the mass to set, before it be permitted again to enter; when this precaution is taken and the lime used hot, the concrete will be found quite impervious to water, and will gradually indurate, perhaps as well in that situation as in any other. The setting of mortar is an immediate process, its induration an after one.

If to remove the water for a sufficient time during the construction be impossible, recourse should be had to those limes which possess the property of setting *under* water, as the blue lias and others.*

The setting of ordinary limes results from the absorption of carbonic

* The lias clay is a rock of the secondary strata, and more especially remarkable as abounding in fossil remains.

acid gas from the atmosphere; to permit this therefore, contact with the atmosphere is essential, but having set, water will not at all injure it*—lime itself is soluble in water, but when combined, in certain proportions, with carbonic acid gas it becomes chalk, which is insoluble. The property of setting under water however—the possession of which constitutes the difference between mortars and *cements*—results from the presence of iron, or certain metallic oxides, by which, *it is supposed*, the water in the mixture is decomposed, and an insoluble compound formed; the rationale of this phenomenon, however, is not clearly understood, and, although—having made many experiments—much might be said upon the subject; this, perhaps, is not the place in which to enter upon it, and it must suffice here to remark, that cements in which iron is present *have* this power.

Puzzolana†—which was extensively used by the Romans in water-works, and which, mixed with Aberthaw lime in proper proportions, Smeaton pronounces to be the most perfect composition for water mortar—contains in 100 parts, 55 or 60 of siliceous earth, 20 argillaceous, 5 or 6 of calcareous earth, and 15 *to* 20 *of iron*.‡ Puzzolana is often formed artificially, and Smeaton says iron scales from the forge, pounded and mixed with ordinary lime, will produce an equal effect with puzzolana if treated the same. The *Cendre De Tournay* and Dutch terras are also esteemed to make excellent water cements, as does iron stone or hard burned tiles, ground and mixed with quick-lime. §

At the New Church, Dovor, some of the foundation, being under water every tide, is compounded at the bottom to a height of 18 inches of Roman cement and the sand and stones of the beach, in the proportions of one part cement to six of beach. The upper part is filled in with a concrete of Hythe lime and the stones, &c. of the beach in the same proportions.‖

At the Dock Yard, Woolwich, Mr. Ranger is now constructing with concrete a river wall 1800 feet long. A row of piles being first introduced, the bottom is rammed with stones, and upon these is placed the concrete composed of blue lias lime and Thames ballast. The face is formed of

* Unless the water should hold in solution an *excess* of carbonic acid, which in some situations it does; in that case, the water would dissolve it.

† An earth, the product of volcanoes, originally discovered at Puzzuoli, in Italy. It is also found in France and England. The only preparation necessary is, to pound and sift it.

‡ Bergman, as quoted in Stuart's Architectural Dictionary.

§ Telford.

‖ Until this church was commenced, and it is but just now finished, concrete was unknown at Dover: since then it has been generally used.

masses of these materials molded in boxes as stones, and behind it the rough concrete is filled in, in the usual way. From the situation, the men are unable to work but between the tides, and the water usually comes over the concrete directly after it is put in; it sets, however, so quickly from the nature of the lime, the use of hot water, and care in the execution, that when the tide goes out it is found as hard as a rock, and in no way injured by the water.

Whether too much dependance is not placed upon it in this case, by exposing it, when completed, to the constant and powerful action of the river, before it can have become perfectly indurated—altered too as it is in actual principle by molding into distinct pieces—is a moot point, and one, perhaps, that time will best determine; it is certainly putting concrete to an extreme test, and every care should be used in so employing it.

In the Experimental Dock at this same place, so called from the partial failure which has there occurred, much money has been unprofitably spent, in consequence, as it appears to me, of using *separate molded masses of concrete* for foundation, instead of employing it as one whole—an entire subversion of its principle—and that too when the great difficulty to be overcome was that of stopping out the springs.

I have before said that the lime* to be employed in the formation of concrete should be *well burned, ground, and used fresh*, but its importance in order to the excellence of the composition will warrant the reiteration. If exposed to the atmosphere it absorbs carbonic acid gas, from its great affinity thereto, and, becoming nothing more than chalk or lime-stone, its goodness is destroyed; this must, therefore, be prevented. In like manner is it, also, if the lime has not been well burned—i. e. if the carbonic acid gas, originally with lime constituting the stone, has not been driven off. All lumps, therefore, which will not slake readily should be rejected; but as when ground this defect cannot easily be discovered, the greatest care must be exercised to prevent the introduction of improper materials; in order to which (when it is practicable) the grinding should be done upon the premises. When ground, the lime should be sifted through a fine sieve, and the remainder again passed through the mill, and it is hardly necessary to say that the mill must be protected from the weather by a

* Lime is procured by burning chalk, limestone, oyster shells, corals, &c. by which process the carbonic acid gas, in them combined with it, is driven off. These substances are termed calcareous, from the Latin word *calx*, signifying lime.

Lime itself is a compound of oxygen, and a peculiar metal, which Sir Humphery Davy, who made the discovery, termed *calcium*.

shed or otherwise. In some cases, where grinding was impracticable, the lime has been pounded and sifted, but this is always disadvantageous—more especially to the builder—and should be avoided if possible.

In ordinary cases, stone lime should always be employed—that from Dorking when attainable. Both Dr. Higgins and Mr. Smeaton contend that chalk lime, when well burned and used with care, is fully equal to stone lime. Experiments, however, do not appear to bear out their views, probably from the difficulty of fulfilling the chief condition; and I should advise, notwithstanding the authority of such names, that chalk lime be never used for the purpose of concretion.

The sand, like the stones, should be of various sizes—coarse and fine—and should be sharp and clean, leaving no stains when rubbed between the fingers; of attention, however, to these points I have already shown the necessity when treating of Ballast.

In the neighbourhood of the sea, a good concrete may be formed by a due admixture of stones and sand from the beach, with lime, as instanced at Dovor. Salt water, or sea sand, may not be used advantageously for plastering, or work exposed, in consequence of the affinity of the saline particles for moisture, which causes them to absorb it from the air; but for underground or water-works, as concrete, Smeaton and others have proved that mortar prepared with them becomes harder than with the ordinary materials—it will harden but not dry—and the same opinion, as we have already seen, is held by Belidor, who says, describing the preparation of *Béton*, "qu' on doit prendre de l'eau de mer pour les ouvrages maritimes."*

With respect to the use of concrete—specially so termed—other than in the preparation of foundations, it will be seen that I have said little in the foregoing pages; it has been employed, however, extensively in construction for some time past as a building material; sometimes being filled in between planks placed sufficiently apart to form the thickness of the wall, in a manner precisely similar to the *Reimpiuta* of Palladio, before mentioned, and at others cast in moulds of various forms and sizes, faced up with lime and sand, and fastened in their intended situation (or set, as it is termed) with the like materials. In each of the blocks thus formed, two holes—through the whole thickness—are left, in order to their being raised

* No stronger proof in confirmation can be needed, than the fact that both salt water and sea sand were used in the construction of Eddystone Lighthouse.

into the proper place, (the use of a Lewis, as employed for masonry, not being expedient) and into these, which communicate with two grooves, formed purposely in the bed of each stone, a grouting of lime and sand is poured after the stone has been set, serving to connect and bind together the whole mass. Of the first method, the sea wall lately constructed at Brighton may be cited as an example; and of the second, Sir Edward Codrington's house at Brighton, the guard house in St. James's Park, a proprietary grammar school now building at Lee, the River wall at Woolwich, and many others.

For this method of building, a patent has been granted to Mr. Ranger, before named, by whom all of the above works—with others more important, but which do not occur to me—were constructed. To offer any opinion regarding the durability of these constructions, so recently executed, would be unwise, as this must depend, in a degree, on the goodness of the materials employed, and the care used in the execution. As regards the excellence of the *principle*, however, few can have any doubts; the process is the natural one by which a large portion of the rocks constituting the crust of this our momentary residence has been formed; the vast series of Transition rocks consist wholly of an accumulation of rubble, as it were—the *debris* of the previous strata, formed into a mass, and cemented together by a calcareous deposition; and sometimes called by us, from this circumstance, Conglomerates, or pudding stones, and by the Italians *Abrezzia* (broken). They are, in fact, but immense beds of concrete—the prototypes of the *artificial* formation*—and it is conceived we have abundant proofs, in the various ancient works thus constructed, and enduring to this day, some few of which, although but few, have been quoted in the preceding pages, of how well this may be imitated: to dilate longer, however, upon that which appears to be already so universally admitted would be useless.

Here then I will conclude my remarks upon the important subject before us, and in so doing, I would crave permission to observe, that to amass the information here set forth, imperfect and trifling as it may be, has occupied much time,—has been attended with some trouble. The concrete substratum having been lately so generally employed in construction, all persons know *something* of its preparation and its properties; but this general use being comparatively recent, few, if any, know *everything;* and it was therefore necessary, independent of personal observation and experiment, to consult the experience of many persons, in order to arrive at anything

* Most of the colored marbles are of the transition series.

like a perfect view of the subject; with what success this has been done remains to be seen, at all events, it is hoped that the matter thus collected may afford a foundation, upon which, hereafter, other and more able hands may erect a valuable superstructure.*

APPENDIX A.

Extracts from Specification for building New Bridewell, Westminster.

FROM EXCAVATOR'S WORK.

The contractors are to execute all the works within the department of the Excavator, and to find proper workmen, and all the necessary engines, pumps, troughs, planks, braces, struts, barrows, and all other materials, implements, and utensils, of whatever kind or description, that may be required in the excavation of the ground for the proposed building, gateway, lodges, and boundary walls, in forming, in the best manner, a foundation of concrete under the same, and in filling in the ground in the whole area within the boundary wall, making up and levelling as proposed by the various designs exhibited. * * *

The ground for the boundary walls surrounding the prisons, is to be dug out, with sufficient slopes, to the depth of 5 feet from the mean level of the sand or gravel, or 11 feet 6 inches under the level which is marked upon the sections as the highest-tide-level, so as to admit of the concrete foundations being formed under it, to the level and to the width and slopes shown upon the sections. * * *

The contractors are to sink an engine-well near the middle of the ground, or where directed by the architect, for the purpose of draining the water from the foundations while the same are being put in, and keeping the water from the concrete until the same is perfectly consolidated. The well is to be 6 feet in diameter, and sunk to the depth of at least 8 feet below the level of the concrete under the boundary walls, or 19 feet 6 inches below the highest tide-level, with a stout curb and brick steening; the bottom of the same to be planked.

Also, to provide, fix, and keep constantly at work, a good low-pressure steam-engine, of the power of at least eight horses, to which are to be attached pumps of a proper size for pumping out the water drained into the engine well from the sites of the buildings and boundary wall, to the depth

* To Mr. Macintosh and Mr. Butler, as mentioned in the body of the Essay, I offer my acknowledgements for much practical information.

of at least 5 feet below the bottom of the concrete under the boundary wall, or 16 feet 6 inches below the highest-tide-level; and also for the purpose of grinding the lime for the concrete; with a temporary engine-house and shed over; also over the mill-stones for grinding the lime.

The water is to be kept clear of the concrete until the footings of all the buildings and walls, and the several drains, cesspools, and other works under ground are completed, and for a period of one month after the completion of the same, or until the said architect shall be satisfied that there is no necessity for continuing the same.

* * * * The contractors, in case it should be necessary to excavate for artificial foundation below the proposed dimensions for building, or trenches, to be paid by the yard cube at the price specified in the list of prices hereafter set forth.

ARTIFICIAL FOUNDATION.

The contractors to find all machines, scaffolding, planks, strutting shores, rammers, barrows, measures, and all necessary tackle, materials, and implements for carrying into full effect the forming a good, substantial, and proper foundation under all the several buildings, walls, and parts required and shown by plan to be executed, and to effectually prevent the water getting into the foundations during the execution of the works, and such other periods as have been described in the excavator's work, and to keep constantly employed all trucks and carts that may be necessary.

The contractors are also to provide best sharp Thames coarse gravel, free from all loamy or other impure mixtures,—and if with too great a proportion of sand, the same to be screened from it—to be carted to the ground for the purpose of being mixed with best Meastram or Dorking lime, in the proportions and substance hereafter described, and forming a concrete body under the whole of the boundary walls, and under the whole area within these walls, excepting only such parts elsewhere pointed out.

The concrete is to extend 6 feet outside the plinth of the boundary wall, also 6 feet within the plinth of the walls, the buildings, and steps next the octagonal court yard; and the slopes are to extend on the base in the proportion of one and a half horizontal to one perpendicular, except as shown by sections.

The ground to be rammed in solid round the whole of the slopes of the concrete next the octagonal court yard and boundary wall.

Provide stone lime from Meastram, Dorking, or from elsewhere, if of equal quality and approved by the architect. Grind the same to a powder, in a mill worked by the steam-engine, or by horses. Mix one ninth of

lime, after being ground in a fresh and pure state, with eight ninths of gravel and sand, to form the concrete or substratum.

The materials above described are to be well mixed, without water, by manual labour, and then a sufficiency of water is to be added, and the substance is to be thoroughly worked and mixed together by manual labour; in which state it is to be pitched or thrown from a height of at least three yards above the stratum, in all stages of its formation, and then to be immediately puddled and trodden down by men constantly employed in the works, to level, combine, and properly cement the whole together.*

The depth of all the concrete, or artificial foundation, under the boundary wall is to be 9 feet, and to the whole area within the same (excepting only the octagonal court yard, and the parts sloping throughout) it is to be not less than 7 feet.

Under no circumstance is the lime to be mixed with a greater quantity of gravel than can be used in a proper state, nor is a larger quantity to be pitched or thrown in one place than a depth of from 9 to 12 inches in thickness, which is immediately to undergo the aforesaid process of puddling, levelling, and kneading down; and by a succession of raisings, or steps, the whole thickness required shall be formed, so as to become one solid mass, or stratum, fully equal to support the superincumbent weight intended to be placed thereon. The upper surface is to be made perfectly level, and grouted with hot lime and sand on the foundation walls being commenced.

To provide 4000 cubic yards of artificial foundation, or concrete, more than shown by the drawings, to be used under the drains, cesspools, sewers, and where directed.

No excavation will be allowed on the premises for gravel, nor will any belonging thereto be permitted to be used.

APPENDIX B.

One cubic foot of Concrete, when dry = about 140 lbs.

RELATIVE WEIGHTS.

One ton of	Granite	=	13½	feet.
,,	York flag	=	15	,,
,,	Concrete	=	16	,,
,,	Portland stone	=	16	,,
,,	Bath stone	=	17	,,

* The direction to "puddle" differs from the opinion expressed in the foregoing Essay, but is admitted in justice to the architect.

A Letter from ROB^{T} ABRAHAM, Esq. *to* THO^{S} L. DONALDSON, Hon^{r}. Sec^{y}., *on the Concrete used at Westminster New Bridewell.*

Read at the Ordinary Meeting held Monday 18th January, 1836.

Torrington Street, Russell Square.
16th January, 1836.

My dear Sir,

It would afford me much pleasure and satisfaction, could I more fully comply with your request than I am now able to do, and present to the Institute of British Architects the samples of concrete I had made previous to, and during, the execution of the artificial foundation of the Westminster New Bridewell, where about 60,000 cubic yards were deposited during the years 1830 and 1831. Specimens were made on the ground some months before the works were commenced, and other specimens were made during the progress of the works, for the purpose of satisfying me that the very best and most economical combination for an artificial foundation was provided for in my specification. The soil on the appropriated site for the Prison, was alluvial, very loose and unequal, and much below high-tide-level; more than ordinary precaution was therefore necessary in the adoption of material and system for the formation of an uniformly solid foundation.

The result of the experiments made during the progress of the works was fully confirmatory of the views originally detailed in contract, which required an admixture of 1 part lime to $\frac{6}{9}$ gravel, containing sand in the proportion of $\frac{2}{9}$ of the aggregate, or, in other words, $\frac{1}{9}$ lime, $\frac{2}{9}$ sand, $\frac{6}{9}$ gravel. In making a few practical remarks, I beg to state, that care and regularity in the execution of the work is of great importance, success very much depending upon the degree of precision and uniformity preserved in proportioning the components; it is therefore necessary, that such a system be adopted of depositing the material, on delivery, either in rectangular or other shaped heaps of uniform size, as will render obvious any deficiency of lime or sand, and be an invariable measure for the requisite quantity of water.

The mode of throwing in the concrete is also important, very great advantage being obtained from the rapid consolidation arising from pressure when cast from a height, instead of being laid in steps or layers. The degree of expansion peculiar to concrete when thus executed may be

noticed; this takes place immediately the operation of slacking has occurred, giving an urgent reason for the prompt use of the material after mixing, and shewing the necessity of using the lime in a perfectly fresh and pure state; large landings are raised very perceptibly by this peculiarity, and the crown of a brick arch has been known to fracture from its effect. It must, however, be stated, that this expansion occurs subsequently to an original loss of some magnitude upon the measure of unmixed material, 27 cubic feet of gravel, (with its due proportion of sand included) together with 3 feet of ground lime, and a little more than 4 cubic feet of water, yielding only 24 feet of concrete.

The gravel found most suitable was that which was obtained between Westminster and London Bridge, holding a much less hungry sand than that procured West of Westminster Bridge, called the red gravel. The specimens sent are No. 1, a sample of natural concrete, which occurs in the formation of the shoals between the bridges of London. Nos. 2 and 3 are masses which I have had in my possession since 1831, during which period they have been exposed to weather; their numbers and descriptions are gone, and I cannot precisely state their proportions. No. 2, however, appears to contain more than $\frac{1}{3}$ lime, and No. 3 contains a still greater proportion, the gravel having, I think, been sorted and cleaned.

The other specimens made are not, I regret to say, in my possession, they consisted only of a variety of combination of ingredient, tending to prove the superiority of the method adopted, in illustration of which I send a specimen, No. 4, which was yesterday, after the application of great force, with a heavy crow bar, extracted from its bed under one of the prisons; and, as a further practical illustration of its efficacy, I venture to add, that in no part of the extensive and weighty superstructure of prisons and wallings has the slightest appearance of settlement been discovered, a fact which I trust will sufficiently demonstrate the uniform goodness of its quality throughout.

I take advantage of this opportunity, to offer for the acceptance of the Institute, a plan of the Prison, upon which is shewn a section of the concrete, and also the original and present surface level, with the high-tide-level.

Apologizing for this hasty commmunication,

I am, my dear Sir,

very faithfully yours,

ROBT. ABRAHAM.

T. L. DONALDSON, Esq.

An Account of the Methods used in Underpinning the long Storehouse at His Majesty's Dock Yard, Chatham, in the year 1834.

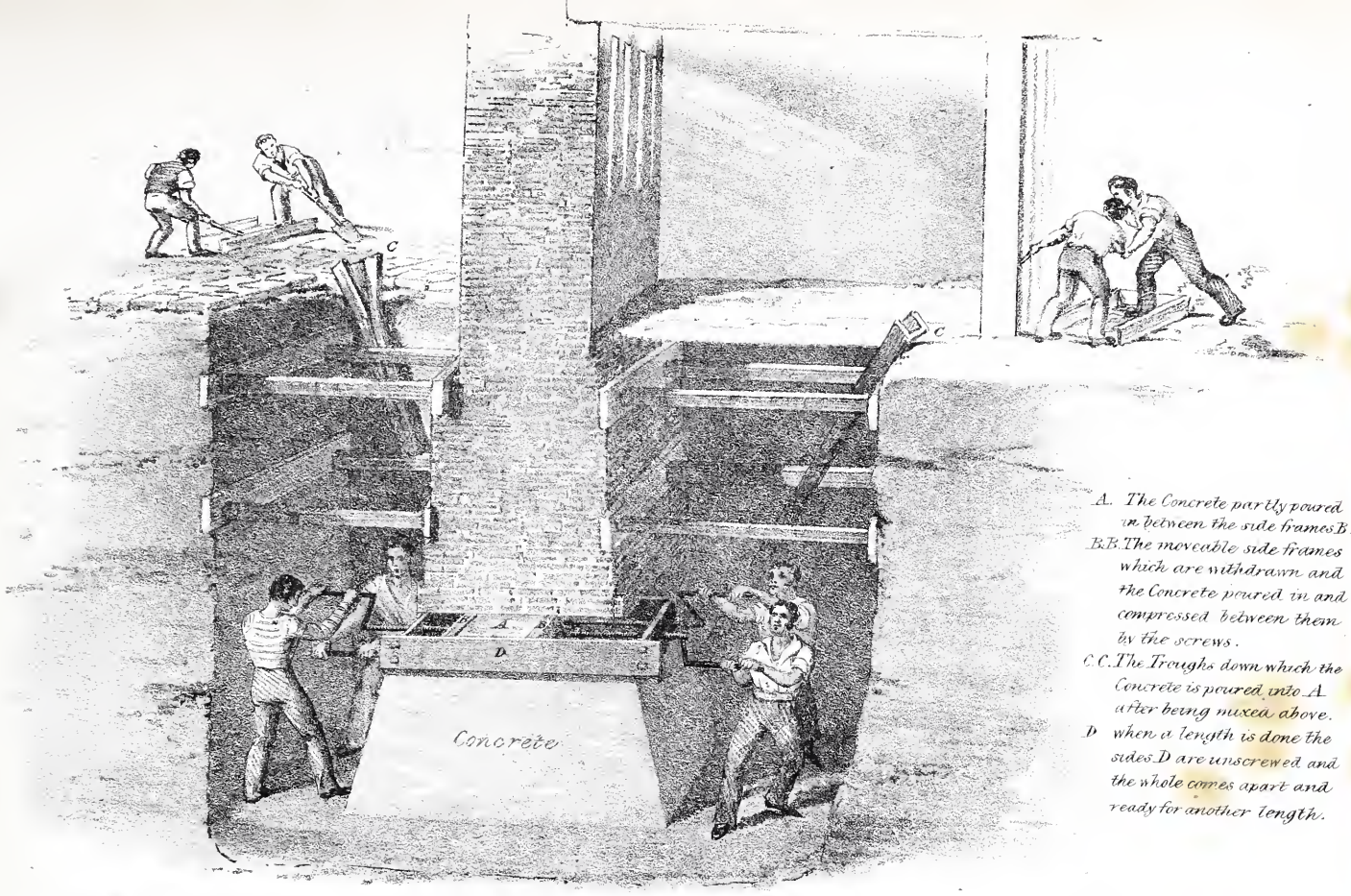
BY GEORGE L. TAYLOR, FELLOW.

Read at the Ordinary Meeting held Monday the 4th of July, 1836.

THIS Storehouse, which is 540 feet in length and 50 feet in breadth, and which contained on five stories vast quantities of stores of all descriptions, had for some years shewn very serious defects in its walls and floors; and the arches of the exterior walls were nearly all affected by the settlement of the piers. My attention had been called to it frequently, and temporary measures had been adopted, such as shoring the walls to prevent their actually falling, as they were in some places as much as 10 inches out of perpendicular, and had sunk also in parts very materially, indeed at one place as much as 9 inches. The timber floors had also been shored or propped up to carry the weight of the stores, which were very heavy, consisting of cables and cordage, sails, and other fittings for ships, piled up to the ceilings. The consequence of this shoring of the floors to sustain the weights on them, and relieve the pressure from the outer walls, was, that the walls themselves continuing to settle down, the girders had no longer any bearing on the walls, and there was a space of 2, 3, or 4 inches under most of the girders, and they, being pressed down at the ends and upheld in the middle, had curved materially, and in some places had been broken by their having to bear this unequal pressure produced by the sinking of the outer walls.

It was generally supposed, that the walls of the building were built on piles, or on sleepers of timber, but the precise nature of the foundation was not known.

In 1834 the building became so much worse, as to be considered dangerous, and I was directed to report what was best to be done. It was generally considered to be so bad, that nothing short of pulling down and re-building it would do. Two very material objections presented themselves to this measure, first—the immense cost, which was calculated at £70,000., and, secondly—the great inconvenience and expence of removing all the bulky



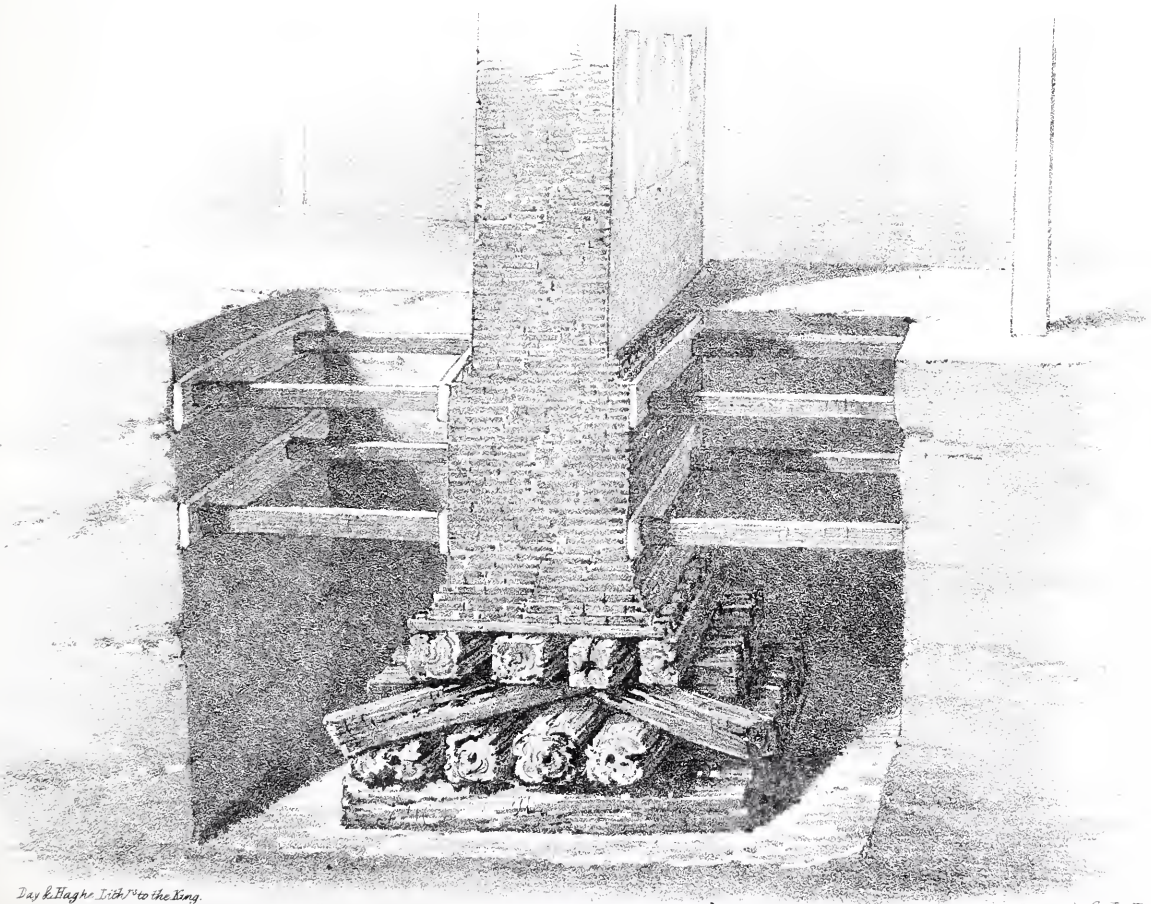
A. The Concrete partly poured in between the side frames B B

B.B. The moveable side frames which are withdrawn and the Concrete poured in and compressed between them by the screws.

C.C. The Troughs down which the Concrete is poured into A after being mixed above.

D when a length is done the sides D are unscrewed and the whole comes apart and ready for another length.

Sections shewing the Method of underpinning with Concrete, the Store Houses, Chatham Dock Yard.



Day & Haghe Lith.rs to the King.

G. L. Taylor Fellow Arch.t

Section of the Foundation as found on Excavation.

stores therein, and the want of proper places in which to stow them away during the operation. It became therefore necessary, to endeavour to uphold the building, by means of underpinning the walls. My first impression was to adopt the system so successfully used at the Custom House, under the direction of Sir Robert Smirke, by Messrs. Baker, viz.—by putting a foundation of concrete under the walls down to a solid ground, and up to within 3 or 4 feet of the bottom of the wall. This 3 or 4 feet Mr. Baker proposed to be done with brickwork in cement, pinned carefully under the old wall. The space of 3 to 4 feet was considered necessary for a bricklayer to work in, to be secure that each brick was at the last perfectly set and wedged up, so as to leave no cavities, and this brickwork in cement became the main portion of the expense in the calculations made.

Having received directions to procure Mr. Baker's terms for this operation, we proceeded to open the ground in several places, to discover the nature of the foundations, and their state, so as to form the necessary calculation of the cost. We found that the walls were generally constructed on planks, laid on one tier of longitudinal and one tier of transverse sleepers of oak, and of very large scantling. This timber was all more or less in a state of decay, and according to the extent of that decay, in the different parts of the building, the settling of the walls had occurred. We considered that the average of the depth we should have to go below the level of the ground was 15 feet, and on that datum the calculations were made for the operation. Mr. Baker's tender for these works was £8,800. It had occurred to me that the great expense of the brickwork in cement, which, as was observed, formed a *large* portion of the expense, might be saved by pressing the concrete, by means of strong screws, up to the under side of the old wall; and I had suggested it to Mr. Baker, but he declined to do it, and did not consider it could be made secure in that manner.

The sum appearing to the Admiralty Board very large, I was directed to obtain terms from some one who would undertake to adopt the method of screwing up, and consequently Mr. Ranger was applied to, and delivered in an offer to do it to the extent of 15 feet in depth, as before calculated, for the sum of £3,300. The matter being considered an experiment, it was deemed prudent not to engage for the whole, but to do one pavilion, or break, at the end, which was in the worst state, and the estimate for this portion was £600.

The work was commenced at the North-west return, or end; that angle of the building exhibiting the worst appearance, having actually sunk 9 inches, and overhanging 10 inches.

The ground was excavated on each side of the wall, and 2 feet below the timber, without which it was found impossible to extract the timber. The depth here was 16 feet. The timber, being extracted for a length of 6 feet, the bottom of the wall, was found to be well compacted, and tolerably smooth; and the bed to commence our concrete foundation upon was solid chalk. The width of the wall at bottom was 7 feet. Boards were placed on each side to that width, in order to confine the concrete, which was mixed on the ground above, and poured down through troughs. The concrete had been prepared in the manner for which Mr. Ranger had procured a patent right. The peculiarity, and consequent superiority of this concrete, I have since found to be,—that he provides lime of the strongest quality, freshly and equally burned; then ground, also as fresh as possible, to the finest powder; and passed through a fine screen, which extracts all imperfections. It is then mixed with hot water, in the proportion of about one-seventh of lime to six of sharp river gravel; and will set in a few minutes into a compact form, in a box or mould; and this takes place in a short time so effectually, that building to any height may be procceded with at once. This mass of concrete having been brought up between the boards to within a foot of the bottom of the wall, large slates were laid on and bedded—on these slates a strong iron frame was placed, 12 inches in heighth, (the width of the wall) and 4 feet in length, having four very strong screws, two on each side of the wall, by which the sides are compressed with great force. The concrete being poured in from above between these moveable side frames, they are pressed together, say within about 9 inches, and the mass squeezed up to the under side of the wall. In a few minutes it is sufficiently set to admit of the frames being drawn back; a fresh quantity of concrete poured in from each side, when the frames are again screwed up, and so on till the concrete is squeezed in the whole width of the wall. This operation having been effected for two or three lengths of the end, and in the direction of the North-west angle, the foundation appeared to grow worse, and deeper shelving toward the river. More timber was also found, and indeed so very unsatisfactory were the appearances, that, although the walls were very effectually shored, I considered the risk too great at that particular part to proceed with underpinning, and recommended the front wall of that part, to the length of about 40 feet, to be taken down. This was ordered, and effected with a very imprudent haste, during my absence; so that in three days the whole perpendicular weight of the wall, 60 feet high and averaging 4 ft. 6 in thickness, was taken on the concrete so recently put in; and on examina-

tion, to my great surprize, it had not subsided in the least. This imprudent trial, however, gave me great confidence in the material and method of applying it. On excavating for the reconstruction of this angle and portion of the front, timber was found piled up 9 feet in heighth, and we excavated to a depth of 20 feet to obtain a solid foundation.

The rebuilding of this portion, in cement, became an easy operation; and the rest of the whole storehouse proceeded on the plan detailed with the iron frame and screws, and was satisfactorily completed in four months, without any inconvenience to the Service from removal of stores; and the work progressed regularly when the men got into the way of proceeding. Many local difficulties occurred during the work, such as the influx of water, &c. which were overcome; and at the Eastern end of the building, the whole of the outside and cross walls were found to be on piles, the heads of which and the sleepers had incipient decay, where alternately wet and dry, but the lower parts of the piles, which were continually wet, were sound, and allowed to remain, and upon them we proceeded in a manner similar to the rest.

The effect of the application of this experimental system of undersetting, I consider satisfactory, inasmuch as it was performed in one season, and, including the extra depths to which we were obliged to go, the expense did not exceed one-half the estimated cost of the method at first proposed, which was to have occupied two years.

GEO. L. TAYLOR,
June 1836.

Metal Roof at Hungerford Market,

BY CHARLES FOWLER, HONORARY SECRETARY.

Read at the Ordinary Meeting held Monday, 15th February, 1836.

IT was required to cover the area of the lower quadrangle to as great an extent as could be admitted, without darkening or obstructing the colonnades at the sides, for the purpose of accommodating the Wholesale Fish Market; in the arrangement of which, the situation of the supports was in some degree limited; and it was also required that the covering should be so constructed as to admit the greatest possible quantity of light and air, at the same time to avoid most carefully the liability of being rendered impure or offensive by absorbing any portion of the fishy matter, either in substance or exhalation.

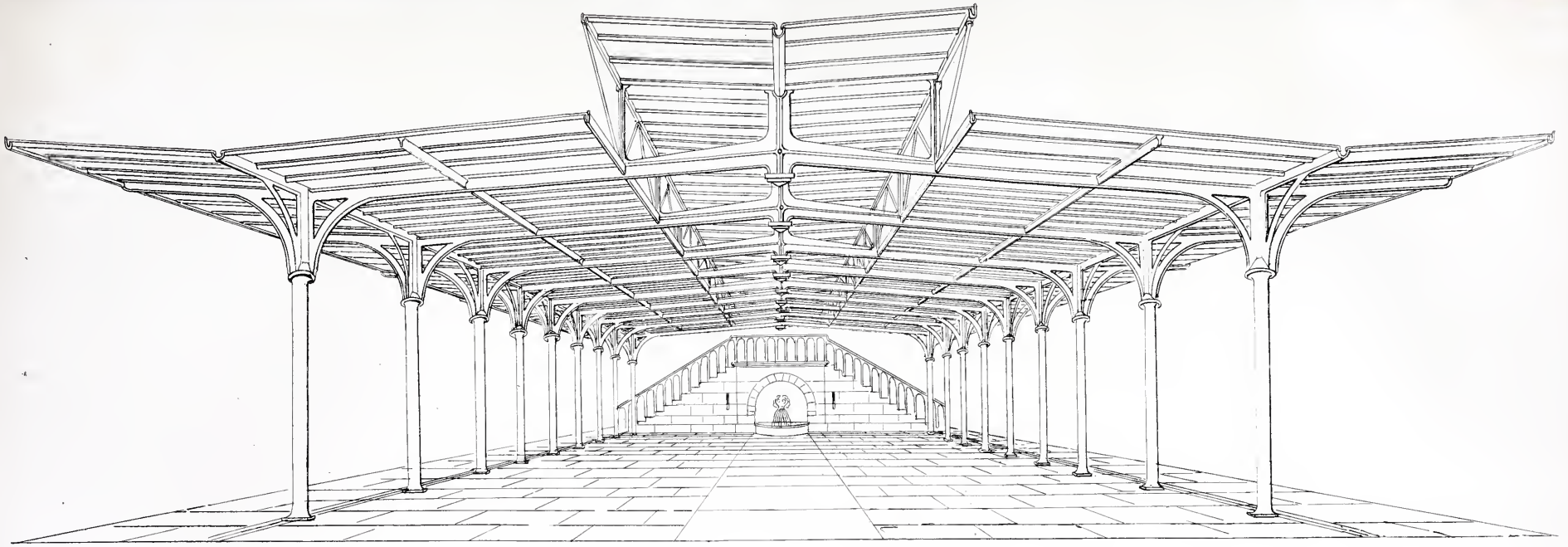
These considerations led to the adoption of the form and construction now exhibited; in which the conditions required to be fulfilled in this instance have pointed out the course that has been pursued. The great importance of avoiding impurity, in the first place suggested the necessity of excluding the use of timber; as experience has proved that, even when planed and painted, the exhalations leave a deposit on the surface, and produce an offensive odour: the whole is therefore formed of metal, the frame-work being cast iron, and the covering of zinc, 20 oz. to the foot, laid on a lining of felt, soaked in tar, to avoid the contact of the two metals.

The chief peculiarities to be noticed in the construction, are the absence of any tie or lateral abutment; the former being inadmissible from the want of height, and the latter impracticable by the detached position, and having no connection with the colonnades.

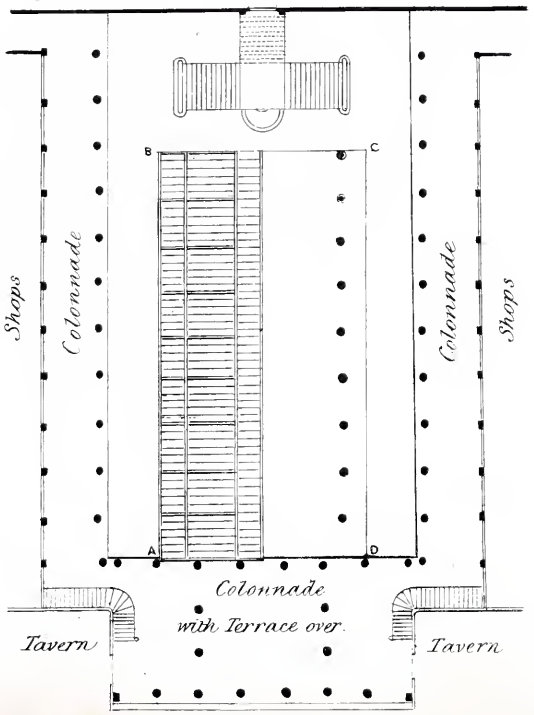
It must be obvious, that if the projecting arms beyond the columns were nearly equal to the middle portions of the ribs which meet and unite in the centre, an equipoise would be produced, and then no tie would be required; but it has been before stated, that the position of the supports was limited, and in such a way as to throw a vast preponderance into the central compartment, producing of course a proportionate degree of lateral pressure.

To counteract this, an abutment is formed in the centre, by elongating

HUNGERFORD MARKET.



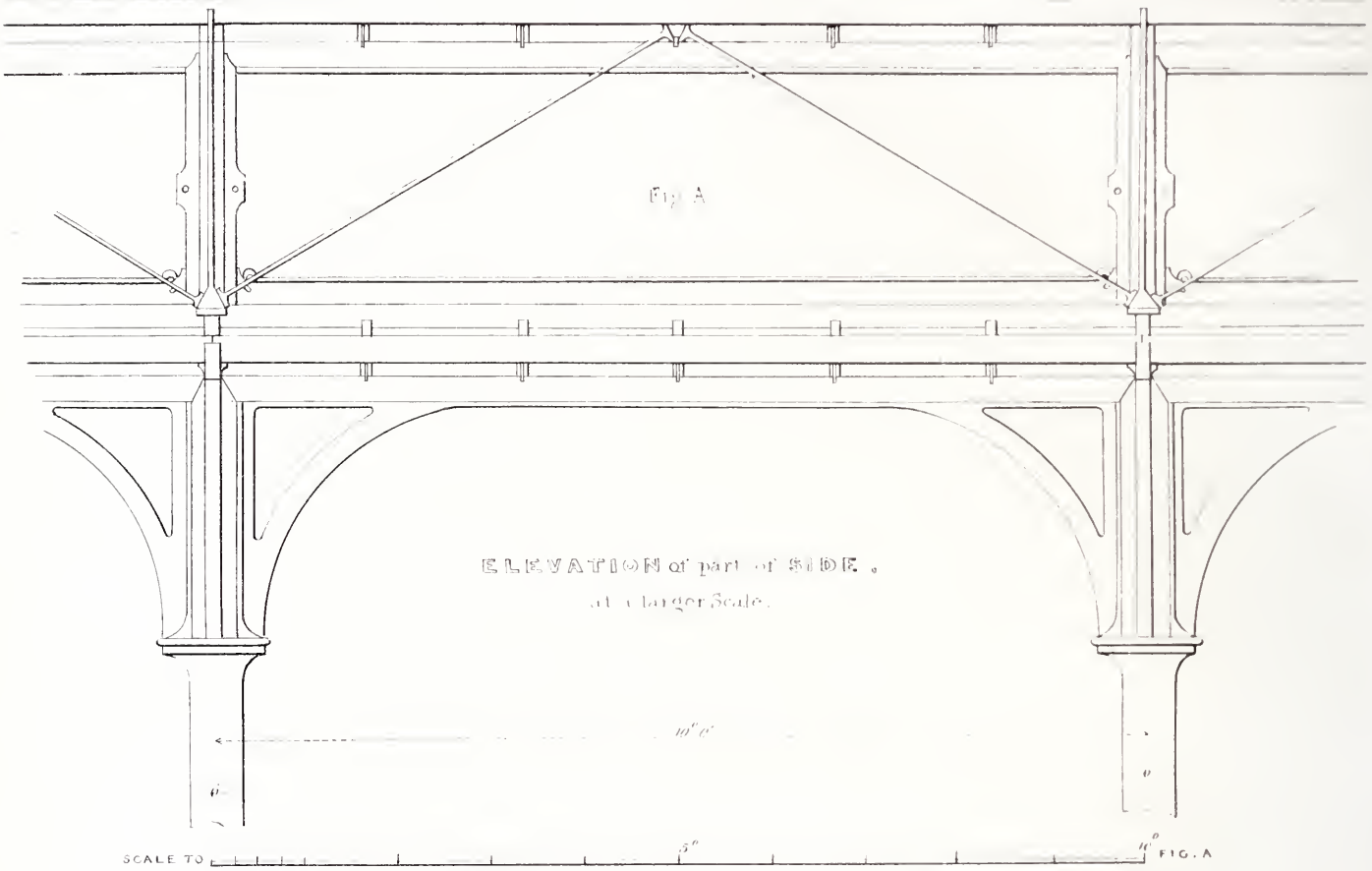
PLAN AND VIEW OF THE METAL ROOF IN THE CENTRE OF THE FISH MARKET, ERECTED A.D. 1835. A.B.C.D Area of Roof.

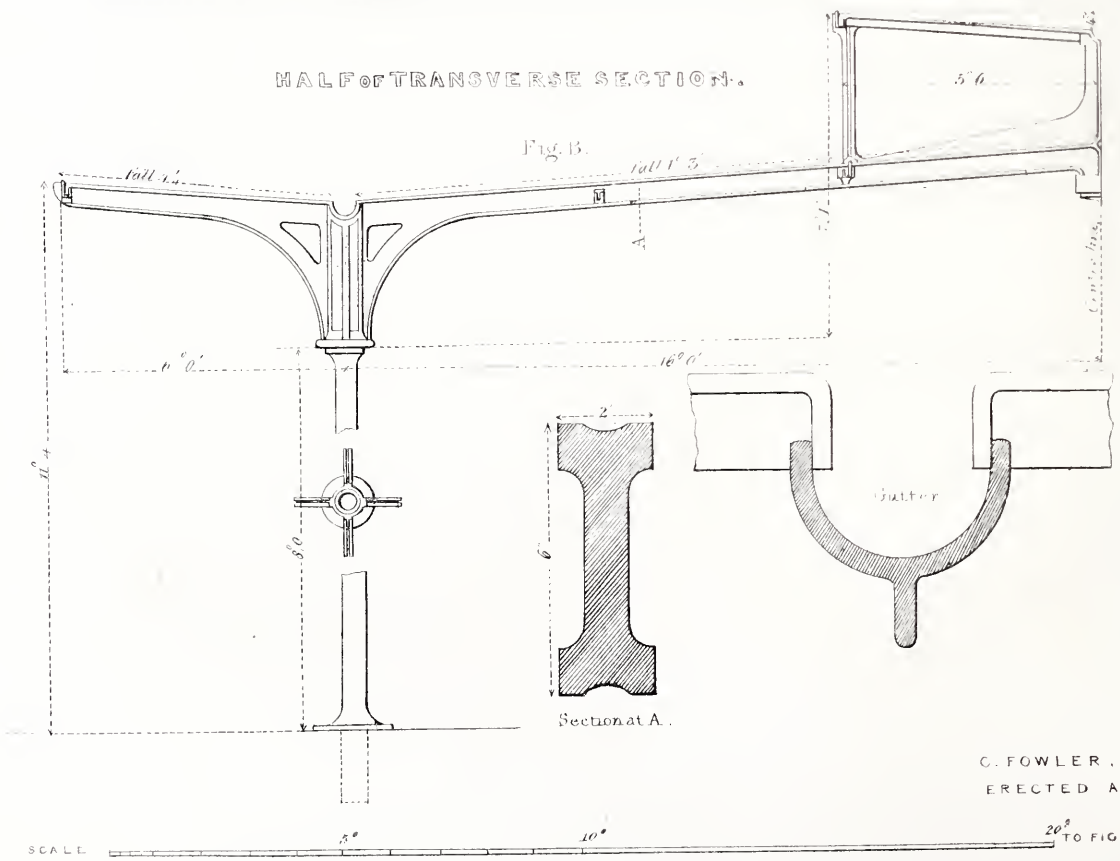


C. FOWLER, ARCH.T
ERECTED A.D. 1835.

HUNGERFORD MARKET

Roof in the Centre of Fish Market.





Day & Haghe Lith.rs to the King

the junction of the two half ribs, principally upwards, by which the pressure is spread over a greater extent of surface, tending towards the top; and this abutment is confined and secured at bottom by a wrought iron collar, put on when red hot, so that in cooling, the contraction tightens and completes the union.

The application of this principle of a central abutment being considered novel, it gave rise to much discussion as to its efficiency; accordingly a series of experiments were made at Messrs. Bramah's, (who executed the work,) upon models; the result of which was, that this form bore nearly double the weight of a strait bar of the same section.

I was induced by the suggestion of practical men, to increase the substances of the rib beyond what was originally intended; but, from the result of all the tests and experiments, I feel assured that such increase might safely have been spared.

Each pair of ribs forming one span weighed 33 cwt. 3 qrs. 3 lbs.; and the whole of the cast iron work, including columns, gutters, &c. weighed 32 tons and 32 lbs. Total expense, £706. 7*s*. 11*d*. Area covered was 3960 feet, equal to full 3*s*. 6*d*. per foot, or nearly £18. per square.

With respect to inverting the usual form in the upper compartment of the roof, viz.—from an external to an internal angle, it will be obvious that it affords the advantages of bringing the drainage of the surface into one central gutter, instead of two, at the eaves; and further, that the eaves being elevated in consequence, instead of being depressed, a larger portion of light and air is thereby admitted. The same principle applies in both respects to the outer or side compartments projecting beyond the columns. It may be proper to notice, that the gutters in each case serve also as bearers, which tends to simplify the construction. Each alternate column forms a water-pipe; and all the columns are connected with the main ribs by the latter having sockets, which include the whole depth from the top to the springing of the curves, the columns running up into them, and then filled in with lead; *they* also have sockets, which run down about 2 feet through the pavement, into the spandrils of the vaulting underneath.

The wrought iron diagonal braces and connecting rods serve to give general connection and stability to the whole structure, the efficiency of which has been by experience fully established.

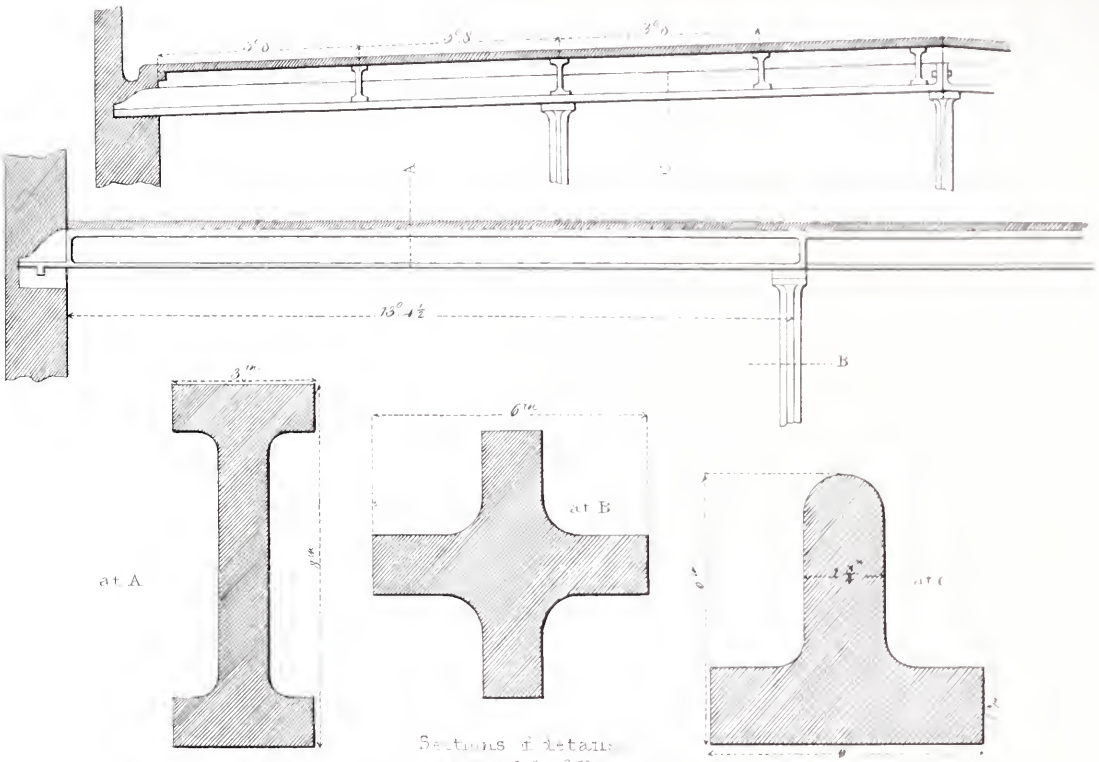
Each pair of ribs was tried with a weight in the centre of 1550 lbs., being one-half of the greatest weight they were liable to, viz.—from a heavy fall of snow, but practically equal to the whole load; and the deflection was only $\frac{1}{16}^{\text{th}}$ of an inch.

With respect to the zinc covering, it may be observed, that as the great difficulty attending the use of it arises from its continual expansion and contraction, according to the changes of temperature, and the consequent liability to get loose or imperfect, it is here contrived to obviate those difficulties by uniting the edges of the sheets by a roll of the same metal, which embraces them so closely as to prevent their getting loose, at the same time leaving free scope for the action and reaction. The rolls are confined to the iron rafters by T pieces tapped into them. With these precautions, it has been proved in this case, that zinc might safely be employed as a covering, but, from experience in many other cases, I have found that it is not generally suitable, and that the general construction of buildings will not admit of such provisions as are necessary to guard against its objectionable qualities.

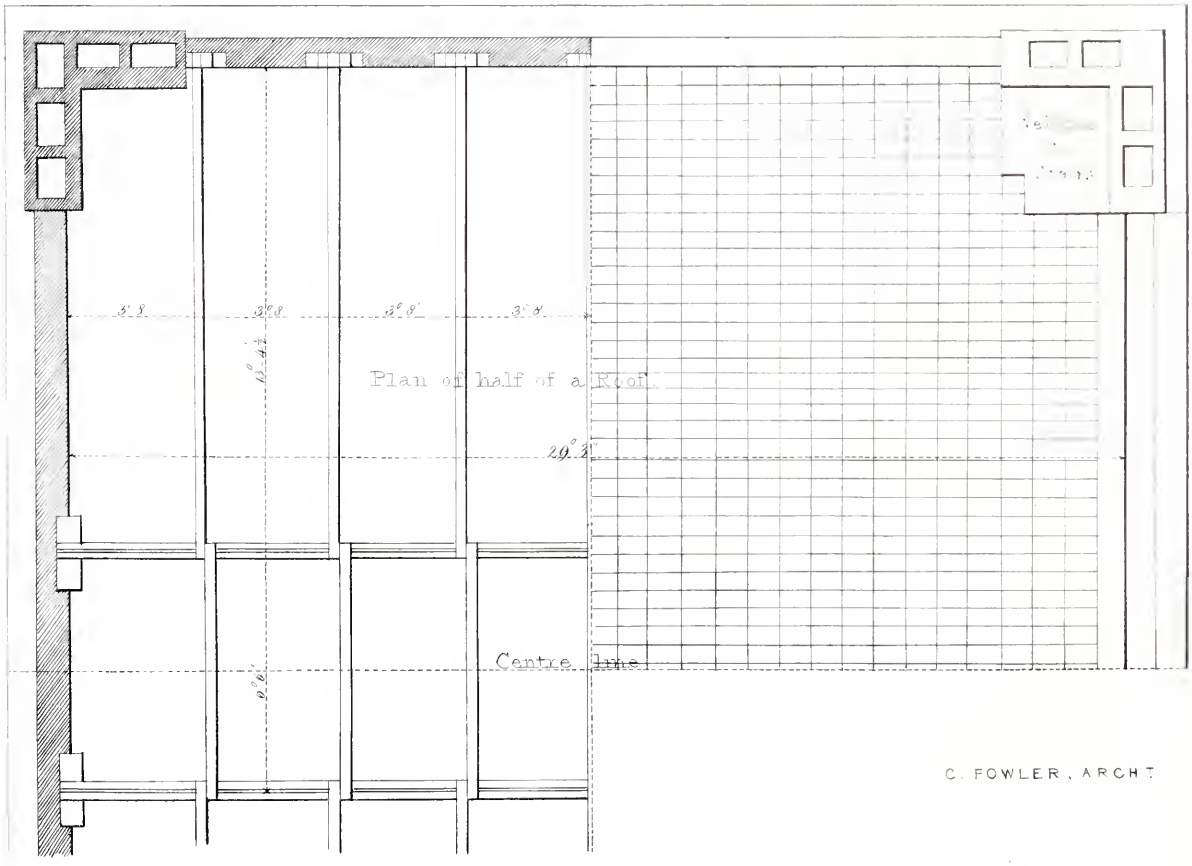
CHA^{S} FOWLER.

Gordon Square, February 15, 1836.

TERRACE ROOF ON TAVERNS AT THE HUNGERFORD WHARF.



SCALE OF 1 0 1 2 3 0 5' 10' 20 Feet TO SECTIONS



C. FOWLER, ARCHT.

SCALE 1 0 6 3 0 5' 10' 20 Feet TO PLAN

Day & Haghe Lithrs to the King

On Terrace Roofs,

BY CHARLES FOWLER, HONORARY SECRETARY.

Read at the Ordinary Meeting held Monday, 9th May, 1836.

IT may generally be considered, that a flat roof is more convenient and beautiful than a sloping one; but the expense of covering substantially with lead is an objection in most cases, and the greater part of the substitutes for that metal, that have been resorted to, have proved insufficient. Copper and zinc, of the thickness or weight commonly used, are too slight, and they are in many respects unmanageable. Various compositions have been tried, in which tar and other ingredients that resist water have been combined, but they have all failed from their insufficiency to withstand the action of heat also, which exhausts and decomposes all materials of that description. Even with lead there are objections as applied to a terrace, arising from the inconvenience of the projecting rolls, and the liability of the flashings and other parts being disturbed or cut away from wantonness and mischief, or theft; also, that a leaded roof on timber offers no resistance or impediment to fire.

It is, therefore, an important desideratum to obtain some mode of constructing flat roofs or terraces free from these objections; and, in erecting my own dwelling, I was induced to adopt the suggestion of a practical man, to cover the back part which projects from the main building with tiles embedded in cement, and laid upon cast iron bearers.

As this part of the house rises only one story above the ground, it forms a terrace at top, approached from the landing of the staircase, and serves as a garden, having a covering of gravel and mould of about 9 inches thick, the weight of which is about 820 lbs. to the square yard, independent of the additional load of rain water, and of persons occasionally going upon it. The whole is supported on cast iron bearers or ribs, about 3 feet apart, having a curved rise of 9 inches, which gives form to the terrace, and serves to drain it both ways.

The covering is composed of three courses of common plain tiles bedded in pure cement without sand; and, in laying them, laths or small slips of wood were used, resting on temporary bearers between the iron ribs, the

laths being shifted, as the work advanced, in the course of about half an hour after being laid. Particular attention is required to bonding the tiles both ways, and they are rubbed down closely upon each other, much in the same manner as a joiner glues a joint.

The gutters are formed by setting up the tiles against the parapets, shaping them into a curve, and giving a slight declivity towards the outlet; and as there are no joints or drips to be provided for, all this is effected with great ease and compactness.

In this case, a bed of coarse gravel was laid underneath the garden mould that the water might percolate through it, and by which means is avoided the having any greater quantity of moisture than is compatible with the proper state of the plants. A lath and plaster ceiling is formed underneath, on joists attached to the lower flange of the iron ribs.

Some leaks have occurred to this roof, in consequence of unequal settlement in the walls; and, in every instance, they have been effectually stopped with great ease, by raking out and enlarging the crack, and then running in cement.

The experience in this case is important, inasmuch as it exposes the contingencies to which this mode of covering is liable, both as to how they arise, and in what manner they may be remedied or prevented; and it is remarkable, that this is the only instance in my own experience of any defect whatever having occurred. It also serves to shew the necessity of providing a very solid and stable construction for the reception of such a terrace: therefore, timber, from its tendency to shrink, is not admissible.

The other instance to which I shall advert, will appear at first to be particularly unsuitable, or difficult, in regard to the construction of the building, for introducing a terrace, of materials liable to become defective by fracture, or requiring to be effectually secured against such a liability: I mean the roofs of the two taverns on the Hungerford Wharf. In that situation it was very desirable to have flat roofs, that might be available occasionally for viewing the scenery which that situation commands, and particularly any public spectacles on the river. To effect this, by means of a leaded roof, would have been particularly objectionable in this case, from its being so much exposed to wanton injuries; and with regard to a terrace of tiles and cement, there was the difficulty of obtaining sufficient stability on the summit of a building of five stories, with the precarious settlements that usually attend the internal construction of floors, partitions, &c. This difficulty, however, has been effectually overcome, and after more than four years' experience and rough usage, no defect whatever

has occurred; although there have been frequently more than seventy persons at a time in a space of less than a thousand feet, with forms, tables, and other accompaniments; subject also to this mass being occasionally concentrated at particular points, and with a considerable degree of movement.

To obtain a solid and immoveable support for the whole terrace, the following course was adopted. First—the walls, which in this upper story are only $1\frac{1}{2}$ brick thick, are secured with chain-bars at the level of the attic floor; and the iron bearers, or joists, *(b)* lying from North to South, bear upon the walls, and hold them together at the top. The middle portion of these joists rests upon two iron girders, *(a)* embracing and bearing upon the East and West walls, and these girders are supported on iron story posts, (section *c*) which are brought up in a continued series from the internal walls on the ground floor: those walls being built in cement, to prevent compression. The story posts are carried through the framed partitions, intercepting the heads and sills, which are re-united by iron straps; and thus an incompressible support of brick and iron is obtained for the whole roof, independent of the timbers composing the flooring and partitions;—the result of which is that no settlement, or movement of any kind, has taken place; the materials of the terrace are preserved in an entire state of cohesion, and remain perfectly united to the surrounding balustrades: the gutters also are quite sound, and no water has penetrated in any part. The tiles form a surface agreeable for walking upon, both as to texture and from being non-conductors of heat; which is another advantage over lead, both as regards the terrace and the rooms underneath—also the friction of so many persons moving about has produced but little wear on the surface of the tiles, although they are more particularly liable to that effect at first, from the irregularity of the surface: but, in situations where it may be important to guard against great friction or wear, the tiles might be rendered harder, and more impervious, by means of a few coats of boiled oil and litharge, laid on during hot weather; or the upper course might be formed of glazed tiles.

In those cases, where a covering or roof only is required, I consider that two courses of tiles are sufficient, and I have found them to answer the purpose very well; but where the roof is made accessible, and liable to be loaded with persons getting upon it, three courses should be used, unless the bearings are much reduced within the width already stated.

With regard to economy, I have made calculations from which it appeared, that two courses of tiles on iron joists, amounted to one-third less

than covering with 8 lbs. lead, on fir joists; and I feel assured that the former is by far the more durable of the two.

The terraces over the porticos, at the North and South of the Hall of Hungerford Market, are also constructed in this manner, the bearings being about 4 . 6, and the widest which I have yet adopted. At the fête which was given on the opening of the Market, the South terrace was almost covered with spectators, and it was computed to have been loaded at that time with three hundred and fifty persons. In these roofs, the soffite or lower surface is plastered, and being jointed, has the appearance of stone; this is the most simple and economical mode of finishing, and the whole construction is then rendered in very great degree solid and imperishable.

The result of my experience hitherto, in adopting this mode of roofing, was so conclusive and satisfactory, that I have been led to introduce it rather extensively in some buildings now in progress, including two churches, in which plaster ceilings are superseded—the iron ribs being moulded and formed to harmonize with the general style of the building, and the under side of the tiles plastered to form the soffites or ceilings; and presuming that the conclusions drawn from experience are correct, this mode of construction must be deemed peculiarly suitable to sacred buildings, from its simplicity, durability, and security against fire.

In a very recent application of this covering to the gallery and studio of an artist, the greater part is supported upon wrought iron ribs, formed of $1\frac{1}{2}$ square bars, bent into a bow, with a light rod to tie the abutments. The whole being exposed to view within, and is far from unsightly.

This is, perhaps, the lightest and cheapest kind of support which can be used. In the lesser apartments the tiles are laid on fir joists, and plastered underneath, there being no ceiling; and the walls and other parts being left quite in the rough, it was deemed comparatively unimportant, even if the wood should shrink, or bend, so as to break the covering. At present the whole appears perfectly sound and compact; but I do not think timber should be used for this purpose in any instance where a leakage would be attended with much injury to the building.

The whole of the roofs or terraces constructed in this manner under my directions, including some buildings now in progress, comprise an area of more than 26,000 feet, or more than half an acre.

In the event of the principle becoming generally applied, it will be found susceptible of numerous modifications and improvements. For instance, in respect of the size, proportions, and quality of the tiles, in which hitherto no discrimination has been exercised, as those employed have been

the same as are used for common roofing; probably some other dimensions might be found to bond more conveniently, and their union might be rendered more perfect by holes or cavities, into which the cement would be pressed in laying. Also, in regard to appearance, there is great scope for improvement, as the upper course might be formed with tiles of various forms and colours, laid in patterns or designs, like the tessellated floors of the Romans; the numerous remains of which sufficiently attest both the beauty and durability of such constructions. But, independently of the consideration of beauty, for the display of which this mode of construction affords great opportunity, it possesses the powerful recommendations of being incombustible, economical, and durable; advantages which must be universally appreciated, and of which the architect will be glad to avail himself where there is a sufficient solidity of construction to admit of this mode of covering being introduced.

CHA^{s}. FOWLER.

Gordon Square, April 25, 1836.

On Whinstone Constructions, &c.

BY MESSRS. SMITH OF DARNICK, N. B.

Communicated by THOMAS HAMILTON, FELLOW, Architect, of Edinburgh.

Read at the Ordinary Meeting held Monday the 4th of January, 1836.

HAVING in the course of our business built a number of small bridges, the arches of which were all done of *Whinstone* rubble, we beg leave to offer a few observations upon that description of bridge. We have observed that engineers sometimes fall into mistakes, by neglecting the facilities which the localities of the work often present; because they are unacquainted with them. We have often seen arches of small dimensions constructed of expensive, and sometimes of far-fetched materials, where there was plenty of materials upon the spot, sufficient for the accomplishment of the work, to be had at less than half the expense: and equally good with those employed.

Another error is often committed, arising no doubt from the zeal of the architect, or engineer, to have the work as perfect as possible, and that is, in the specification, confining contractors to use much more expensive, and much larger materials than are required for the work, and in some instances enforcing impracticable methods of employing materials, in the dressing and preparation of them for the work, and in dealing with a material with which they are but imperfectly acquainted. In this way the contractor is often punished, because he cannot perform impossibilities; and the expense to the public is greatly increased, beyond what might have been quite sufficient for the work, had more economical methods been pursued.

From the experience we have had, we are of opinion, that nothing makes a more durable arch than good whinstone, when well built with good mortar, the stone being in its nature proof against the assaults of weather.* We are also of opinion, that, with proper precautions, arches might be constructed of a much larger span than any, which have yet been attempted to be built of this material.

* Whinstone, in one form or another, is found almost over all Scotland.

In this neighbourhood there seems to have been little or no advance upon whinstone arches for the last sixty years, the greatest span being about sixty feet.

We built a bridge over the Ettrick, and another over the Tweed, both in Selkirkshire, in the year 1831; that over the Ettrick had two arches of 51 feet, and one of 26 feet span: that over the Tweed has two arches of 62½ feet, and one of 26 feet. All the large arches are semi-elliptical. They have whinstone arches faced with hewn stone, with hewn stone abutments, piers, cornices and copes of parapets: all of which, with the exception of the facings of the arches and the blocks of the cornices, were included in the estimate, together with the filling up of the ends and spandrils and preparing the bridge for the road. The estimate for the two bridges was £2220.*

We built a bridge over the Hermitage Water, in Liddesdale, of one rubble arch of 63 feet span, upon an elliptic curve, rising from the surface of the water. The height of the arch is about 14 feet; it is partly built of undressed freestone, and partly of rubble limestone. The facings of the arch (or *headers* as we term them) are of hewn stone; the parapets, wing walls, and spandril walls, are coursed of dressed freestone. The expence of this bridge, which was erected entirely by the Duke of Buccleuch in 1832, was about £400.

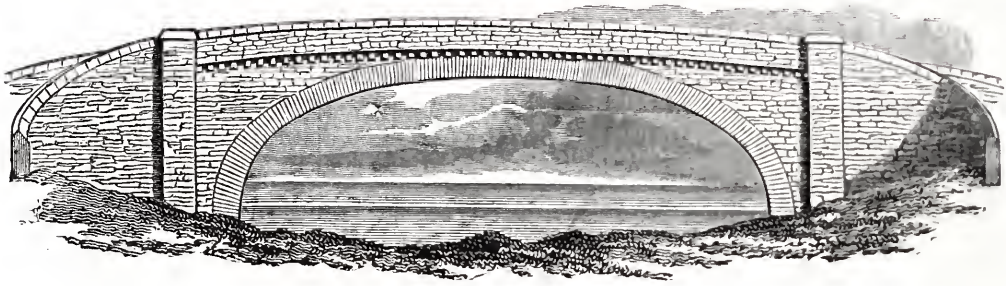
We built one over the Yarrow, at Yarrow Kirk in Selkirkshire, of one arch of 63½ feet of span, and nearly upon the same plan as the last described, but entirely of whinstone, with the exception of the cope of the parapets, which was of hewn stone: it has a block cornice of whinstone. The expense of this bridge was about £360.† The depth of the masonry in this last arch is about 2½ feet at an average, that of the others varies from 2½ to 2 feet, and the 26 feet arch 1½ foot.

The largest arch of this kind which we have done, is one over the Ettrick, at Falshope, belonging to the Duke of Buccleuch, and upon one of the drives connected with Bowhill. This bridge is entirely done of whinstone in every part, the span is 76 feet 4 inches, the rise about 18 feet, the breadth over parapets 18⅓ feet. The depth of the arch averages about 3 feet, excepting a small part on the crown, which is 2½ feet deep. In a chord line of 40 feet, the raised line measured only 3 feet 2 inches. This arch sunk about 7 inches when the centre was struck, and we could not observe one broken stone in the arch. There is one spandril wall along

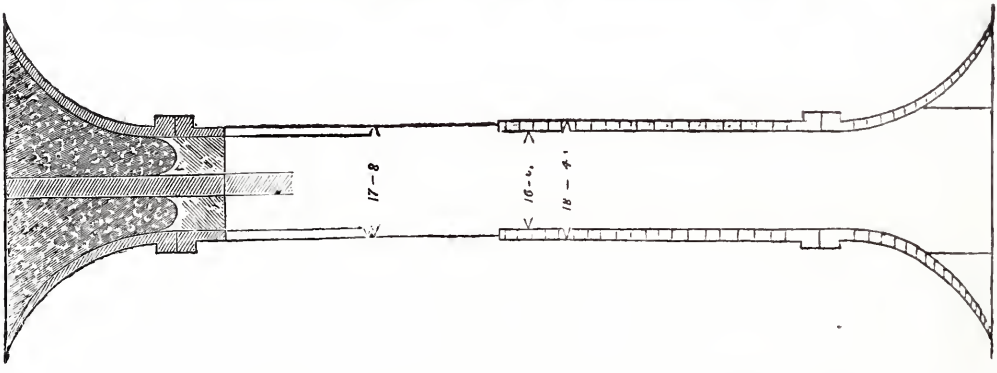
* Say £1300. for the one, and £920. for the other.

† The height of this arch is 13 feet, and it was built in 1833.

the centre of the back of the arch on each side, through which we left temporary holes, as well as through the outer spandril walls, to facilitate the drying of the arch before the centre was struck. The haunches were afterwards filled up with dry stones to the level of the road way, which is upon an inclined plane, as there is a bank on one side, and a haugh * on the other side of the river. The following is a sketch of this bridge.



The parapets project 4 inches over the spandril walls.



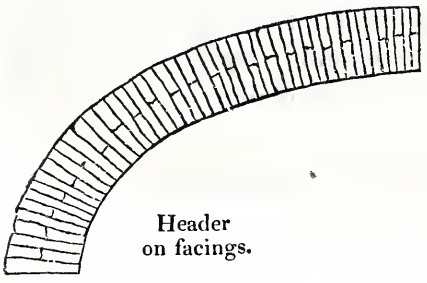
The foundation is a soft clay, without any piling or planking being used.† The estimate for this bridge, the coping of the parapets, and the digging of the foundation excepted, was £360., and the arch stones were to be carted upwards of five miles.‡ The stones composing the arch might average about 2 square feet of area, and many of them required three breadths to make up the depth of the arch, (viz. 3 feet); the average thickness of the stones might be $3\frac{1}{2}$ inches, but varied in thickness from $1\frac{1}{2}$ to 6 inches. The beds of them being generally so much off the straight that we never attempted to lay them in any thing like regular courses, one stone would be laid at the side of

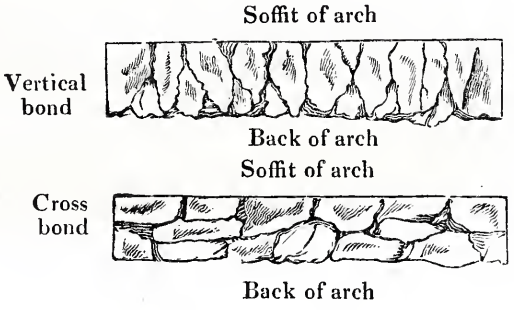
* Haugh, low, lying, flat ground, properly on the border of a river, and such as is sometimes overflowed.

† We would have preferred piling or planking, but this was objected to on the score of expense.

‡ This bridge was built in 1834.

another three times its thickness, and sometimes there would be as much difference in the same stone, which, in consequence, had to be made up with shivers, to prepare for the bed of the next stone. We were at a good deal of pains in laying the stones as close as possible, and in crossing the bond to make the work firm, but we never attempted to dress the stones straight upon the beds. The following sketches will give a faint idea of the way in which the materials are usually laid in the construction of rubble arches.





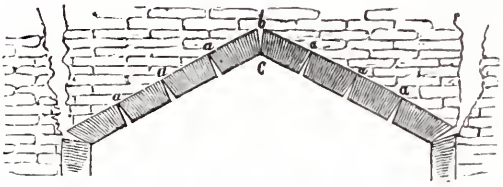
This is a fair specimen of the construction of the arch already described.

What we have found most annoying in the building of rubble arches is the slowness of the *setting* or drying of the mortar, which always causes much delay, before the work is sufficiently firm for the striking of the centre; as, until the mortar is able to bear a good deal of resistance, the arch is extremely supple, and easily bent out of its proper curve. Whereas in the hewn stone arch, the stones being mathematically fitted to one another, its dependance upon the mortar is very little, and it is therefore not easily put out of its proper curve, though the pressure should be unequal; but in the rubble arch, the balancing must be particularly attended to, or it is sure to go out of its proper curve.

The Falshope Bridge stood five weeks before the timber was struck, and it kept its curve remarkably well. Were it not for the expense, Roman cement would be the best mortar for large rubble arches, and in many situations even this would be far cheaper than hewn stone; as with such a cement almost any kind of stone might be worked into an arch, or even the refuse of a slate quarry might be used in an arch of almost any extent.

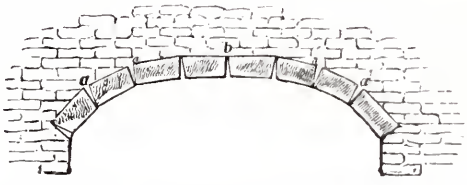
Most of the failures in the building of arches, which have fallen within our notice, have arisen from not balancing them properly, or in striking the centres too soon. It will readily occur to every person, the least acquainted with arches, that when it is properly balanced, the pressure is equal over every part of the section of the arch, that is, between the ex-

trados and the intrados; but when it is unequally balanced, the pressure is wholly upon a very small part of the section, as will appear by the following diagram.



The pressure upon *a a a a a a* being too much for *b*, the arch rises at *b*, therefore the whole weight of the arch rests upon a very small part of the section, and is apt to break the stones at *a* and *c*, where the joints are close.

If the arch be overloaded at *b*, it will present this appearance,



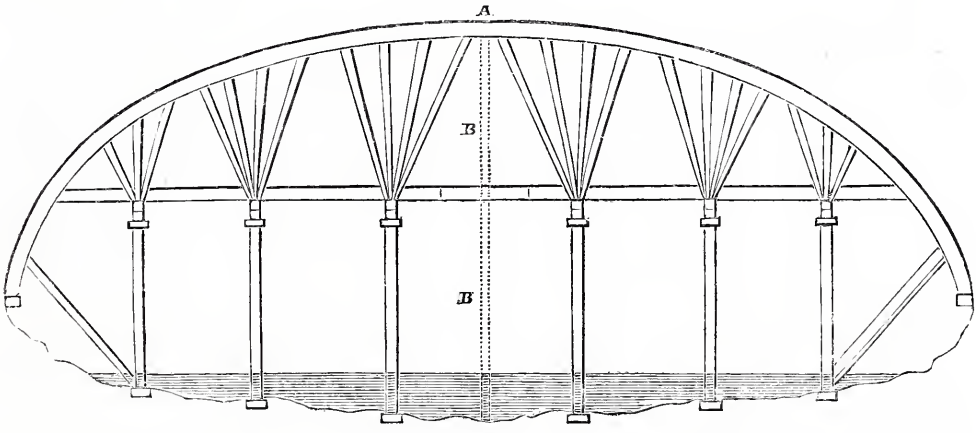
b will sink, and *a a a a* will rise, which will produce the same effect upon the materials of which the arch is constructed, the weight being driven to rest upon so small a part of the joints that these give way, and the arch falls. In both of these diagrams the abutments are supposed not to move, as if that were to take place, (however well the arch of itself were balanced,) it could not stand. This accounts for the materials of even moderate sized arches being frequently crushed at particular points.

We every day see walls carried to a great height, of brick, and even of soft stone, with none of either being crushed or broken; and the reason is, that the pressure is vertical, and therefore equal over every part of the section, which is seldom the case with the pressure of arches. Suppose we take the suspended part of the largest arch in the country, and divide it into two parts with all its loading, and reduce it to a wall, the section of which is exactly the section of the arch cut across the crown, as at *b* in the above diagrams, it would be found that the wall would not be of a very great height, perhaps not more than two hundred feet. We are therefore of opinion, that arches of large dimensions, with proper care in the balancing, might be constructed of much softer stone than is ever attempted.

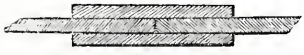
We have often thought, when we have seen brick arches faced with large stones, requiring strong tackle to raise them, that a great saving might have

have been effected by using smaller and less expensive stones, (such as could easily be set without tackle,) without hurting the effect of the building, as the larger the stones are, the greater disproportion they bear to the bricks to which they join.

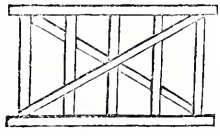
In centering our bridges, for the sake of economy, we constructed them all of home timber, with the exception of the beams upon which the leaves were built, and we did not use any screw bolts, as we found driving nails cheaper and quite sufficient. We always made the arms, or strutts, radiate from a point, under which was placed the tressels, that the whole weight might rest upon the solid. We made the leaves in two halves, thus, joined at A,



the supports B B being temporary. The ring boards were simply butted to each other's ends, with a short piece laid on each side of the joint, thus,

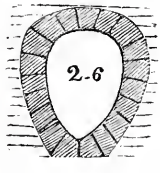


and the leaves were put up whole. The tressels were made in the usual manner, mortised at top and bottom, and fixed with diagonals, thus, and all of home timber.



SEWERS.

We did a good number of sewers at Bowhill of common whinstone of this form, about $2\frac{1}{2}$ feet wide by $3\frac{1}{2}$ feet high, the walls and arch varied from 9 inches to 1 foot thick.



We executed some of smaller dimensions at Abbotsford, of the same form, with hewn stone bottoms, the rest of whinstone, thus.

We did some entirely of stone, within the house, about 12 by 9 inches, cheeked at all the joints, and hewn smooth within, thus.

These last were for water closets, and have answered the purpose very well since they were done, which was in the year 1822.

VENTS.*

We lined all the vents at Abbotsford with flues, made partly of fine clay and partly of common clay. They were made in pieces about 1 foot in length, circular, and varying from 15 to 10 inches in diameter, and about 2 inches thick; they were all made a little off the square on one end, to favour the bends in the vents. When the vents ran straight, the bevelled ends were put together thus, and when a turn was to be formed, they were put thus. They made excellent vents, and are very easily sweeped. These were the first of the kind used in Scotland, to our knowledge, and we suppose in England too. They were done in 1822, and they are now become pretty general in works of any extent.

SUSPENSION BRIDGES.

We erected the first chain bridge that was done in Britain, of *bars linked together forming a chain*, and of which we have sent with this the original plan. There was a small wire bridge done at Galashiels before our's, but the span was short.

Our's was erected in the summer of 1817, over the River Tweed at Dryburgh, in Roxburghshire, and was blown down in a great storm in 1818.

* This term corresponds with our word *flues*, and the word *flues* used by the Scottish builders here answers to our term *tubes*.

The span as executed was 261 feet between the points of suspension. The longest suspending chains were 1 inch in diameter, and they diminished as they shortened to half an inch. The links were about 10 feet long, and were joined in this manner,

the one eye welded, and the other fixed down at the point with a collar. This we afterwards found not to be a good plan, as the point of the hook drew through the collar and then broke off, under a great strain. The bridge was beaten to pieces between the supports, but they, with the back stays, stood firm. We restored it in the summer of 1818, in its present form, and it has stood very well ever since. It was only meant as a foot bridge at first, but horses go along it quite well. The main suspending chains now are four in number, two on each side, $1\frac{3}{8}$ inch diameter, in links about 10 feet long, with welded eyes and coupling links, thus,

They are hung in the catenarian plan, and have perpendicular suspenders at each short link, as most of them are now done. The chains were all made by our own blacksmiths, as well as the rest of the work, but we had no means of proving them. We did the first bridge by estimate for about £560., and we restored it for £240., including the approaches at each end.

The undulating, or perpendicular, motion we found even more inconvenient upon our bridge than the lateral motion, but it was greatly stiffened by a small wooden rail slightly trussed, along each side of the road way. We think a strong trussed wooden railing, for the above reasons, better than an iron one for chain bridges.

DAMP IN FOUNDATIONS OF WALLS.

We had an opportunity at Bowhill of seeing the effect of a coating of cement, which had been laid over the foundation for the purpose of keeping down the damp. In a wall which we took down this was done in a very substantial manner, and it did not appear to have the smallest effect, as the wall was as damp above, as it was below the coating of the cement: the wall had stood twelve or thirteen years.

We have tried a very simple plan in small cottages in damp situations,

which we found very effective. We built all the parts of the wall, under the surface of the ground *quite dry*, and did not use any mortar till clear of the earth; this cut off the communication with the damp ground below, and left the walls quite dry above. This plan can only be adopted in small houses, as it would weaken the walls to found them dry in large buildings.

We have often thought that it would be a good plan, in building a house upon a clay or *tilly* foundation, to take out the earth over the whole site of the building, and a few feet beyond the outer walls, to the depth of $1\frac{1}{2}$ or 2 feet below the intended foundations of the walls; and fill up this space entirely with water gravel, or small stones, which would thus make a kind of artificial sub-soil, which, after being firmly beaten, would be ready to receive the foundations of all the walls of the house, which might be formed in the usual way, and would we think require nothing more to prevent the rising of the damp. This, in many situations, could only be a very small expense, and we have little doubt, from what we have seen, that it would be effectual, as every wall would be completely drained.

HOLLOW WALLS.

In a wing which we built at Pavilion, in this neighbourhood, in the year 1811, for Lord Somerville, we built the walls hollow within. The whole thickness was 22 inches: 10 inches on each side, with an open space in the heart of 2 inches. They had a range of bonds laid between the outer and inner part in every course of 2 feet, which was the height of the boxes used, and the bonds were about the same distance apart. The walls were mostly two stories high, and were all built of common whinstone rubble; they are standing as straight as when they were built, but as they were all lathed inside, it was not proved whether or not such walls would have done for outer walls without lath.

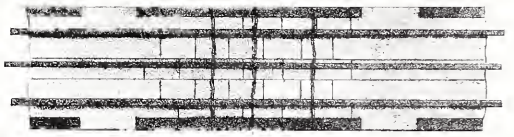
JOHN AND THOMAS SMITH.

Note.—The variety of subjects here referred to by these intelligent correspondents arises from their having sent this communication in reference to the book of *Questions* published by the Institute, and a copy of which had been forwarded to them by Mr. Hamilton of Edinburgh.—T. L. D. Hon. Sec.

EXPERIMENTAL PIER for the PURPOSE of ASCERTAINING the BEST MODE of BINDING BRICK CONSTRUCTION,

by M. J. BRUNEL Esq^r. C.E. F.R.S.

Plan of the Course L.

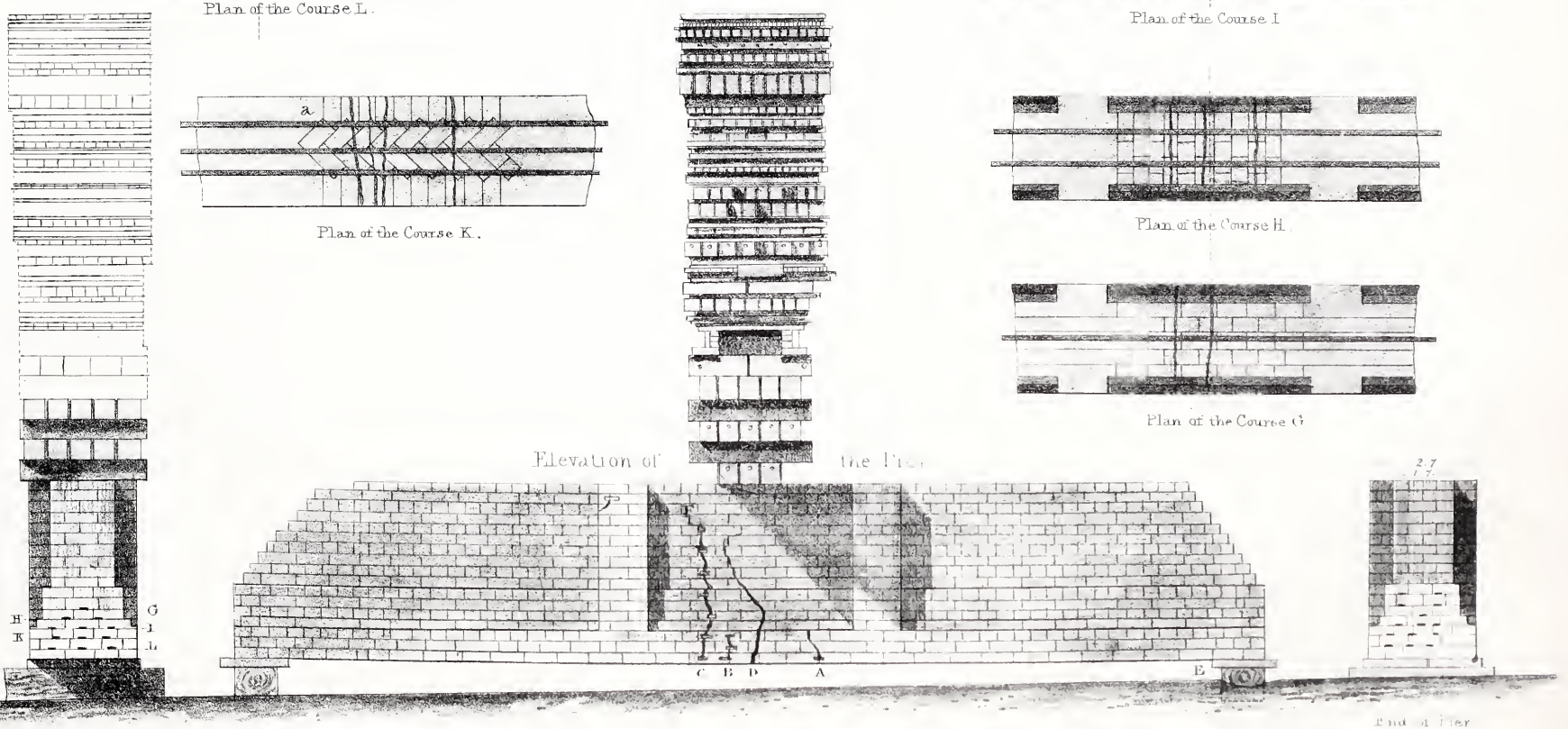


Plan of the Course I.

Plan of the Course K.

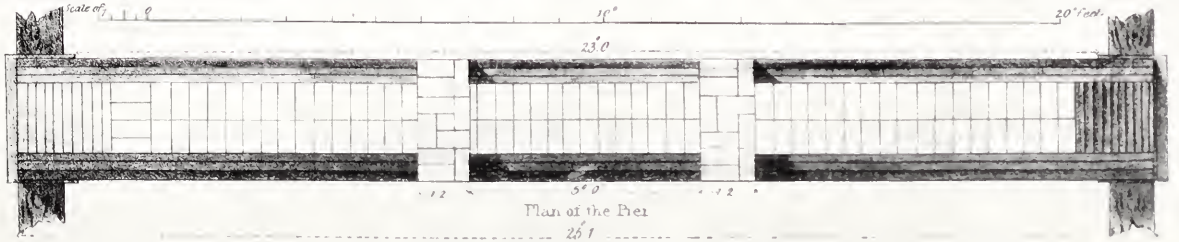
Plan of the Course H.

Plan of the Course G.



Section of Pier.

End of Pier



Plan of the Pier

Transactions of the Institute of British Architects 1836

Particulars of some Experiments on the mode of binding Brick Construction,

MADE BY M. J. BRUNEL, ESQ. C.E. F.R.S.

Described at the Ordinary Meeting, held Monday, 14th of March, 1836.

THE experimental structure, to which this paper refers, was made with a view of ascertaining to what degree the use of iron or of other substances, destined to operate as ties or bonds, could be depended upon in structures of masonry in general, and particularly in some works connected with the Thames Tunnel, as likewise in the formation of arches.

The result, which had already been exemplified by the experimental arch raised by Mr. Brunel at Rotherhithe, was most satisfactory. Still a further experiment, he conceived, was wanting for the purpose of ascertaining the various degrees of strength, that might be obtained from the adhesion of cement or mortar to the surface of iron, and of other substances destined to operate as bonds.

In the course of his experiments, Mr. B. has employed not only hoop iron, but slips of wood, reed, hemp, and even straw, as being preferable he conceived to bars of iron, or to timber of large scantling.

Hoop iron, however, being of easier application, most particularly for an arch, he has confined himself in the experiment before us to the use of the same in the experimental structure represented in the annexed plate.

The hoop iron used was obtained from the King and Queen Iron Works at Rotherhithe. It was laid in the state that it comes from the warehouse, perfectly smooth; a bloom of rust, resulting from a night exposure to the atmosphere, is however preferable for adhesion.

The Roman cement used was obtained from the works of Messrs. Francis and White, near Vauxhall.

The brick structure, as here represented, may be viewed as the base of a pier. The elevation, the plans, and the sections exhibit the position of the ties, twelve in number, and even of every brick. Each tie consists of a slip of iron, 25 feet in length, $1\frac{3}{8}$ inch in width, and $\frac{1}{16}$ in thickness, the whole weighing 93 lbs, equal therefore to a bar $1\frac{1}{16}$ inch square.

The structure was built in October 1835. The two extremities of it

rested upon blockings 12 inches square; the whole mass, consisting of 184 cubic feet, weighed 18,400 lbs.

The first experiments upon it were begun in December following, hardly two months after its completion.

The stress upon the ties was not only that which resulted from the load raised upon it, but that also which resulted from its own specific gravity.

On the 4th of January following, the weight laid over this structure amounted to 11,147 lbs., when a slight crack, hardly perceivable, shewed itself at A, and another on the following day at B; no depression could be detected. These cracks were overlapped with a patch of Roman cement, and the experiment was continued by adding weights at intervals of time. On the 11th of February, the weight amounted to 16,957 lbs.; no alteration could be perceived at the two cracks, the patches remaining quite sound. On the 24th, 627 lbs. were added. About half an hour after, a slight crack showed itself at the patch A, where a second patch was laid. The progressive addition of weight was continued until the 2d of March, when the weight amounted to 19,534 lbs.; no alteration was visible. By the addition of 1,407 lbs. the last patch over the crack A was disturbed, evidently by the agitation caused by the wind during a stormy night. On the 19th of March the weight amounted to 21,281 lbs.; the crack A being increased, it was overlapped with a third patch of cement. On the 28th, further weights having been added, the whole amounting to 24,248 lbs., no visible alteration could be detected, not even at the patches. On the following day, after a stormy night, both patches A B were disturbed, and a fresh vertical crack opened at C, extending to the second course from the top, and another, D. nearly joining the former. Upon adding 1,517 lbs. this crack widened at the lower part, but on the opposite side no crack was visible across the patches, The same day, viz. the 29th, 1,260 lbs. having been added, the whole amounting to 27,025 lbs., no alteration manifested itself at first, except that the blocking E had sunk $3\frac{1}{4}$ inches. Shortly after this weight had laid, and while obtaining some measurement, a crushing noise directed our attention to a brick F, like some person boring a hole from the opposite side, the pulverised fragments crumbling down the face of the wall. The top course on the left having slipt quite out of the course, the whole mass gradually and slowly descended, until it rested upon two sleepers placed for receiving it.

After the iron weight had been removed, the structure, consisting of seventeen courses, was carefully broken up. At the fifth course from the bottom, the slip of iron was found unbroken, and firmly embedded in the

cement, except near the two cracks, where it was loosened and evidently expanded.

On removing and clearing the second course H the two slips were also found entire. At the third course I, two out of the three slips were likewise entire, the middle one was broken short, the ends being $\frac{3}{8}$ of an inch *apart*, and stripped from the cement to the extent of about 7 inches. At the fourth course K, the slip *a* was broken off short, the two others were drawn from the cement to the extent of 14 inches. At the bottom course the slip *b* was broken off, and the two others were drawn from the cement, one to the extent of $13\frac{1}{2}$ inches, and the other somewhat less.

Such were the results of the experiments upon this structure, which may be viewed as *a beam*, loaded to such a degree that the stress upon the ties may be computed at near 120,000 lbs., 90,000 lbs. of which resulting from the load of iron 11 feet high, resting upon a base 18 inches square. It is to be observed, that two bricks were crushed by pressure, before the structure yielded and broke entirely.

The two first cracks A B were not disturbed when the disruption took place at the two other cracks.

The slips were *in no way disturbed* through the length of the courses, except about 10 to 14 inches at *the fractures*. The slips had a slight touch of rust at the opening of the crack A and B: every where else the iron was as smooth and quite blue, as when received from the warehouse.

Although iron presents no objection to its being employed in the formation of arches, in the manner Mr. Brunel has applied it, it would not be equally safe in foundations: he therefore proposes to make use, there, of very thin laths of wood. These, previously prepared, either by being boiled in pitch and tar, or by the anti-dry rot process, would be equally efficient as hoop iron, if properly applied; the same effect may be obtained from reed and hemp. The only preparation, besides that of the anti-dry rot saturation, is to dust the slips or other substances with sand or brick-dust. As for example, a lath of birch, the mean section of which measured .26 of a square inch, having been pitched over and dusted with sand; after having been loaded for eight days with 4,537 lbs., drew slowly and *reluctantly, though only* 4 *feet* 6 *inches of it* was embedded in the cement.

Another lath, 2 inches wide and $\frac{1}{4}$ thick, notched at both edges, was loaded with 3,093 lbs., being embedded in 4 feet 6 inches only of its length. It gave way.

The great shaft of the Tunnel, 50 feet diameter, was secured with twenty-six small hoops, consisting of several slips of wood, (fir); and this structure,

40 feet high, being further secured in the vertical direction with forty-eight bolts of iron, that were drawn out afterwards, descended in a sound state to its destination, as it is now seen.

It is evident that by means of very small substances, operating as ties or bonds, even *the mere fibres of wood*, a piece of masonry may be constituted into a substantial mass or great beam, whereon the superstructures may further be assisted by a few of the same ties with very great advantage, whereas large scantling is found invariably to shrink from its original dimension, and cannot therefore efficiently operate as a tie; nor can any bar of iron of 1 inch square, which presents only 4 inches surface, be adequate to sixteen slips, that present a surface of 32 inches.

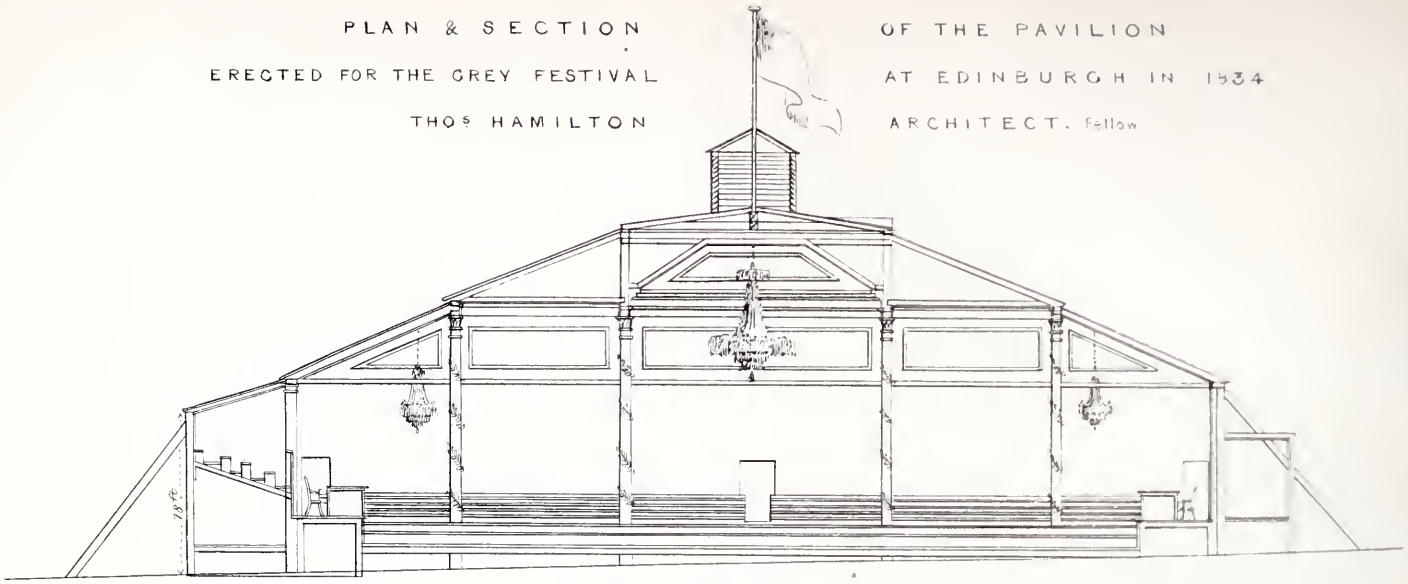
Slips of hoop iron are commonly used with good effect; yet, as complete bonds, no one has probably known how far they may be relied upon; in foundations with porous bricks they may in time prove detrimental, as they may by becoming rusty split the structure. The iron however that is destined for a foundation may be protected by pitching it over in a very hot state, and dusting it either with sand or brick dust. Its adhesive property is considerably encreased by this process.

It is to be remarked, that the twelve slips that were embedded in the experimental structure, must have resisted a detrusive stress of no less than 10,000 lbs. each; and that although those, which were in the lowest courses, must have supported considerably more, not one of the hoops was found drawn out of the cement, or disturbed beyond 14 inches, that is, near the ruptures as stated above.

PLAN & SECTION OF THE PAVILION

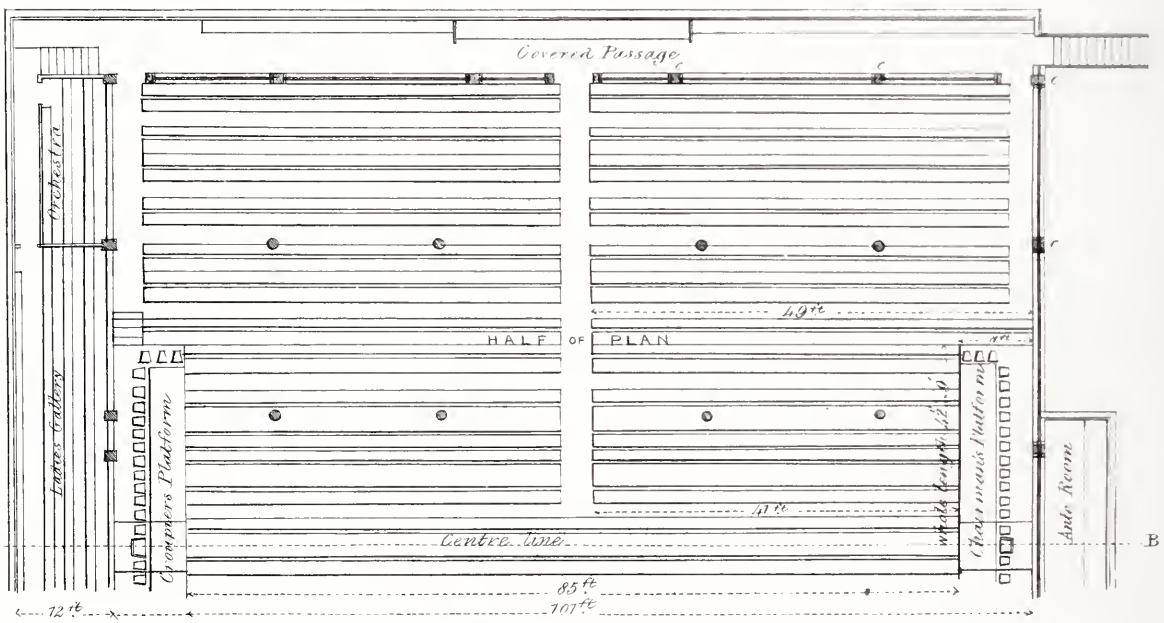
ERECTED FOR THE GREY FESTIVAL AT EDINBURGH IN 1834

THOS HAMILTON ARCHITECT. Fellow



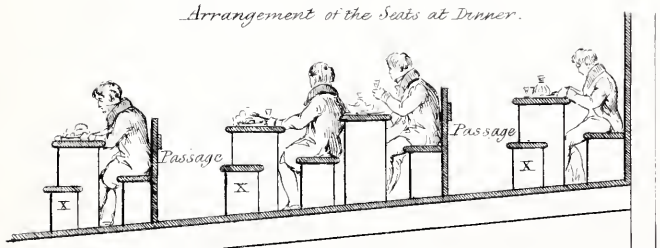
Longitudinal Section on the line A. B.

Scale of 0 5 10 20 30 40 50 60 70 80 90 100 Feet

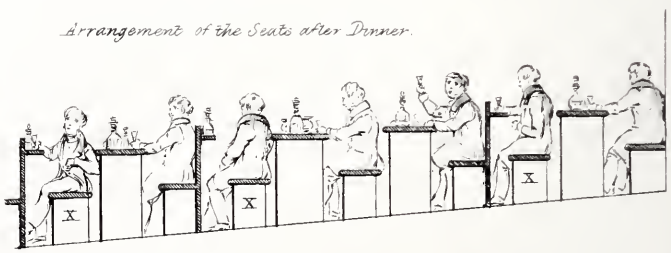


Seats = 19 in. wide.
Double Tables 35 in. wide.
Single Tables 18 in. wide.
Passages 27 in. wide.

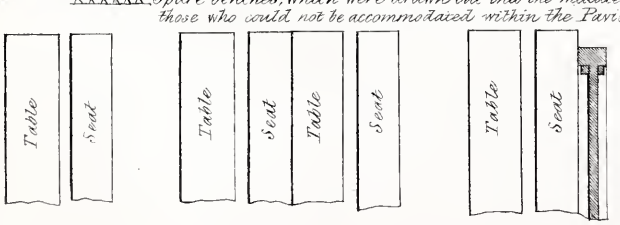
Arrangement of the Seats at Dinner.



Arrangement of the Seats after Dinner.

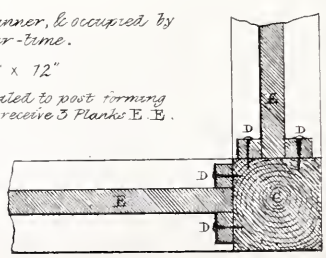


XXXXXX *Spare benches, which were drawn out into the middle of the passages after dinner, & occupied by those who could not be accommodated within the Pavilion during the dinner-time.*



C. *Angle post. 12" x 12"*

D. D. D. D. *Slips rusted to post forming groove to receive 3 Planks E. E.*



Day & Haghe Lith.rs to the King

Transactions of the Institute of British Architects 1836.

Description of the Pavilion erected at Edinburgh for the Festival in honor of Earl Grey, September, 1834.

BY THOMAS HAMILTON, ARCHITECT, FELLOW.

Communicated at the Ordinary Meeting, held Monday, 20th June, 1836.

IN compliance with a wish expressed by some professional friends in London, I have been induced to put together the following particulars explanatory of the form, dimensions, and peculiarities of the "Grey Pavilion," and of the expense of its erection.

As there was no apartment in the city sufficiently capacious for accommodating the numerous applicants for tickets to the dinner on the occasion of Earl Grey's visit to Edinburgh, it was resolved to erect a temporary edifice for the purpose at the eastern extremity of the High School playground. This spot, although far from being so level as could have been desired, was upon the whole well adapted for the purpose, being surrounded by high enclosing walls, and within a few yards of the school-house, in which a kitchen was fitted up, and four apartments were appropriated as dining rooms for about seven hundred and fifty persons, who could not be accommodated in the Pavilion until after dinner.

It was within a fortnight only of the day fixed for the dinner that a temporary structure was finally decided on; consequently my plan was very hastily prepared, and explained to the Committee, who immediately authorized its being carried into effect.

Under such circumstances it was hopeless to expect, that a sufficient supply of timber could be procured of the requisite dimensions for a well proportioned construction, there not being sufficient time for preparing it. I determined at once, therefore, to construct the floors and sides of the Pavilion with much larger timbers than would have been otherwise necessary; and hence, with the extra carriage, labour, and breakage, the expense was much greater than would have been incurred had there been time to mature the design, and to prepare a detailed specification.

The accompanying plan and section will sufficiently explain the general form of the Pavilion. It was exactly 101 feet square within the walls, exclusive of the ladies' gallery, which was 12 feet deep; the side walls were above 18 feet in height; the pillars for supporting the roof were round spars or scaffolding poles, averaging about 10 inches diameter at bottom, and 7

inches at top, covered with dark crimson calico, relieved by spiral laurel wreaths, which with the capitals were richly gilt.

The side walls and ceiling of the interior were wholly covered with canvas, size colored, and emblazoned with the Royal arms of Scotland, the arms of Earl Grey, &c.

The principal cornice or moulding immediately under the sloping part of the roof was gilt, and the compartments at the angles of the horizontal ceiling were decorated with St. Andrew's cross and shield, &c. These decorations were executed by Mr. Hay, assisted by Mr. Roberts of London, whose eminence as an artist and experience in theatrical decorations, were of the utmost value on this occasion.

The whole floor was covered with Dutch matting, with the exception of the platforms, which were laid with crimson cloth.

The principal light was supplied by the great chandelier of the Theatre Royal, hung in the centre, the use of which was given gratuitously in the most handsome manner by Mr. Murray, the manager of our theatre.

At each of the four angles, large crystal lustres were suspended, which, with that in the centre, afforded an ample and well diffused light throughout the whole edifice.

At the side, fronting the ladies' gallery, was a platform for the Chairman and distinguished guests, 42 feet 9 inches long, 8 feet broad, and about 3 feet high; at the opposite end was a corresponding platform for the Croupier, &c.

All the other tables were ranged transversely to the platforms, and extended the whole length of the apartment, with the exception of the passage across the centre, which was 3 feet wide.

The tables on both platforms were of mahogany, 43 feet long and $4\frac{1}{2}$ feet broad, and afforded sufficient room for twenty-four chairs at each.

A centre table, with seats on each side, was continued from platform to platform, so as to divide the floor into two equal parts, and thus the one half of the assembly had to enter and retire on the right, and the other half on the left side of this table.

On occasions such as this, where quietness and attention to the proceedings of the meeting are of paramount importance, it is indispensable that the comfort of every individual should be as perfect as possible, not only in regard to his distance from the speaker, which ought of course to be as limited as circumstances will allow, but also, in reference to the relative position of speaker and hearer; for if any considerable part of a company are seated with their backs to the speaker, they will, although at no great distance, turn round to see him, and change their positions very frequently.

The disturbance thus occasioned, although individually slight, will in the aggregate destroy that stillness, without which no speaker could be properly heard in any apartment of great magnitude, however favorable its general form may be for conveying sound. All the tables, therefore, except the five centre ones, were narrow, and were provided with only one row of seats, facing inwards. The floor was level for about 20 feet in the middle, but being laid with an acclivity of one in ten towards the sides, every person had a full and uninterrupted view of both platforms where the speakers were placed, without any necessity for standing up or turning round for that purpose.

A reference to the plan will sufficiently explain the arrangement of the tables and seats, and they were of the following dimensions, viz.—

1.	Table in the middle, 85 feet long, uninterruptedly continued from platform to platform.	These tables were 33 inches in breadth, and had seats on both sides.
2.	Eight tables, (viz. four on each side of middle table) 41 feet long.	
3.	Four tables, 49 feet long.	About 18 inches broad, being made of two 9-inch deals, and having seats on one side only.
4.	Twenty-two tables, 47 feet long.	
5.	Five tables, 44½ feet long.	
6.	Four ditto, 41 feet long.	

All these tables were covered with crimson calico.

The seats were about 11 inches broad, and the whole tables as well as seats were made of 2½ inch deals, supported on trestles firmly fixed to the floor. The principal transverse passage was 3 feet wide, and a passage was provided between every second range of tables, 22 inches wide, for waiters in attendance during dinner. In these latter passages forms were in readiness for about seven hundred and fifty persons, who dined in the school-rooms adjoining, and were admitted to the Pavilion immediately after the cloths were removed.

By examination of the foregoing particulars it will be found that there was ample seating for two thousand six hundred and fifty persons, viz.—

Twenty-four on each platform, having upwards of 2 feet of table to each	48	
At the other tables during dinner	1522	
Admitted after dinner	750	
Ladies' and music galleries	330	
	2650	persons,

and, including waiters and others who had no seats, the total numbers present were estimated at the time to be not less than two thousand seven hundred and sixty-eight persons.

The following is a description of the general construction, with such particulars of the expense incurred and time occupied in the erection as may perhaps be useful, should any similar structure be hereafter required.

Such American and Memel logs as could be got nearest to the requisite lengths were laid on the ground for carrying the floor, and, as the ground sloped considerably, they were raised to the proper levels by strong props and walls of rough masonry. The distances between these logs or sleepers, to which the uprights for the side walls were also attached, varied from 8 to 10 feet, being regulated by the lengths of the battens and deals delivered, which for the most part were 18 and 20 feet long. The floor was of battens $2\frac{1}{2}$ inches thick, well fastened at the ends, but otherwise with as few nails as possible. The side walls were formed with square timbers for upright posts, placed at distances varying from 12 to 16, 18 and 20 feet a part, being the lengths of the $2\frac{1}{2}$ and 3 inch deals, which were fitted between the uprights and secured by fillets on either side. The uprights were generally kept to their proper position by external diagonals, spiked to the sleepers, which were made to project sufficiently outwards from the floor for that purpose.

The mode of constructing the roof is perhaps sufficiently explained by the section. The part over the platform was laid with $1\frac{1}{4}$ inch deal boarding, and covered with thin lead; the sloping sides with $\frac{3}{4}$ inch deals, well lapped over each other. The large central ventilator was furnished with moveable louver-boards, and on the evening of the dinner (which was unusually mild for the season) they were kept entirely open.

Tuesday, 1st September, and Wednesday, were occupied with preliminary arrangements, marking off ground, &c. The work commenced on Thursday, and was wholly completed on Saturday, 13th September, about half-past 10, P. M. For a whole day and a half, during the operations, it rained incessantly, which materially retarded the work.

It is difficult to give an exact statement of the entire expense, as from the hurry with which the operations were carried on, the breakage of timber for fitting up the rooms in the High School, erecting barricades, altering seating for a concert, which was afterwards given in the Pavilion, and numerous incidental matters, are so mixed up in the several accounts as to render it impossible to separate them; but in round numbers it may be safely assumed, that the total expense was about £1,400., but that £1,000.

would cover all the cost of such another erection; and, that if sufficient time were allowed, it would not probably exceed £700 or £750.

The following is an Abstract of the several Disbursements:—

I. Timber Merchant's Account.

	£.	s.	d.	£.	s.	d.
18,706 lineal feet of deals	420	15	0			
47,191 lineal feet of battens	599	14	6			
2,290.3 cubic timber	257	13	2			
3,177 ¾ yards ¾-inch deal for roof, &c.	198	11	5			
35 spars	54	12	9			
Cartage and sawing of log timber, &c.	61	11	2			
	1,592	18	0			
The timber was brought to public sale, and sold for	992	5	3			
	600	12	9			
Discount	50	12	9			
Sum paid				550	0	0
II. For labor, ironmongery, cartage, brass work, and attendance of Police				318	3	9
III. Upholsterer's Account for sewing and putting up canvas, laying floor with matting, loan of tables, chairs, &c. amounted to	203	9	1½			
Articles sold at public sale	66	7	7			
				137	1	6½
The Upholsterers employed 25 men, in all 114½ days 8 apprentices 31½ days 15 women 45½ days exclusive of taking off canvas, &c. and cleaning tables, chairs, &c. the charge for which was about				10	0	0
IV. The Account for painting and decorating, about				83	0	0
V. Account for canvas for walls and ceiling, supposed about				60	0	0
VI. Gas-fitters for branch pipes for lighting passages, retiring room, &c.				15	0	0
VII. Gas-fitters for use of four crystal lustres, gas meters, lanterns, &c.				42	19	0
VIII. For fitting up large centre chandelier, and replacing it again in Theatre Royal				26	0	0
IX. Gas-light Company, for Dinner	34	9	7			
Ditto ditto, for Concert, &c.	16	4	2			
				50	13	9
The Account No. II. embraces only the nett outlay, without any charge for profit. But the Committee spontaneously presented to Messrs. Smith and Cuthbertson, whose account it was, a testimonial for their services worth fifty guineas, and a similar acknowledgement was presented to the Architect. These incidentals, in the whole, may be stated at				120	0	0
Making the Total Expense				£1,412	18	0½

In order to gratify the curiosity of the Public, the Committee kept the Pavilion open for inspection for three days after that of the Festival; and in the course of that time there was a concert in it. If the proceeds of the concert and the exhibition of the apartment had been deducted from the expense, it would have so far counterbalanced it, but the Committee, with a commendable liberality, gave the entire receipts to the public charities of the City. I have not procured a note of the amount thus obtained and its application, otherwise I would have subjoined it, but I believe the Pavilion was visited by nearly ten thousand persons during the three days that it was open to the public.

It was intended to have incorporated in these notes some explanation of the principles on which the "Grey Pavilion" was constructed in reference to acoustics, the more especially on account of some passages on the subject in the report of evidence taken by the Committee of the House of Commons relative to the new Houses of Parliament. I had no intention to broach any theory materially different from those which are already well known to professional men, but rather meant to have explained my own views in the application of those theories. I find, however, that were I to enter on this topic, I should be led into such details as might perhaps incumber the statements which I have already given. On some future occasion, however, I may be induced to attempt this, when I shall have more leisure to do so. In the meantime, it is necessary for me to state, that I acted in this instance solely upon my own impression of what was consistent with correct theory, and was in no degree influenced by any opinions expressed by Dr. D. B. Reid, as might be inferred from some parts of the evidence taken by the Committee of the House of Commons above referred to; on the contrary, there was a very decided difference of opinion betwixt Dr. Reid and myself on several very important points. It was indeed the promptitude and decision of Sir James Gibson Craig (one of the chief promoters of the Festival) which freed me from all embarrassment at this critical period, he having at once obtained the necessary sanction of the Committee, which empowered me to carry on the work without interference. Before the Pavilion was opened, Dr. Reid publicly disclaimed all responsibility connected with its construction. If I can give credence to the general testimony of those who were present at the Festival, I am warranted in concluding that the edifice fully realized the wishes and expectations of those who took the most lively interest in its erection.

THOMAS HAMILTON.

ANTIQUITIES.

I. H. Strack gez. *gedr. v. Hildebrandt.* *Asmus gez. auf Stein.*

Verlag v. George Gropius in Berlin

On the Polychromy of Greek Architecture.

PRELIMINARY OBSERVATIONS.

The extent to which the ancient Greeks availed themselves of color, to heighten the effect of those master-pieces of architecture, which we owe to their genius, is a question, which has now for some time occupied the attention of architects, travellers, and antiquaries. When the minuter investigations of some of our architects, of whom Stuart and Revett were the first, upon the buildings of Athens, had opened a new field of research, by the discovery of very evident remains of painting upon the architectural members of their finest monuments, it was little regarded, or treated as a fanciful speculation. The researches of more recent travellers confirmed however the statement of those, who had first alluded to the subject, and at length Monsieur Hittorff, honorary and corresponding member of this Institute, in his admirable work upon Sicily, boldly adopted the system of Polychromic Architecture in all its fulness, and asserted that all the members of architecture were painted. This daring conclusion was attacked by Raoul Rochette in his "Essai sur la Peinture sur mur des Anciens," and defended, more particularly in reference to the interior of the temples, by the learning of Latronne, in his "Lettre d'un Antiquaire à un Artiste sur la Peinture Murale des Anciens;"—with what success, it is not our purpose to decide. In Germany the subject has been taken up with equal if not greater ardour; and Monsieur Chateauneuf, our honorary and corresponding member, forwarded to the Library a copy of Dr. Kugler's work, entitled "Ueber die Polychromie der Griechischen Architektur, und Sculptur, und ihre Grenzen," published at Berlin in 1835, and recommended it to the attention of the Institute. At the request of the Council, W. R. Hamilton, Esq. Foreign Secretary to the Royal Society of Literature, has translated those parts of the volume relating to the developement of the system, and connected with architecture. For a more minute investigation of the subject, the reader is referred to the book itself, and to the various works enumerated in the notes.

T. L. D.

INTRODUCTION.

It has long been held as a fundamental maxim in the doctrine of Æsthetics,* or the Principles of taste, that the essential character of the architecture and plastic art of the Greeks was based singly and exclusively on form; that is, on the reciprocal action of proportions in space:—that the eye could only apprehend these proportions by outlines, or contours, and the gradations of light and shade:—and that the application of color in these arts must be rejected, as entirely out of the question. The facts, that remains of colour had been found on single monuments of Greek art, and that the ancient writers frequently make mention of this kind of Polychromy, were either wholly neglected, or explained as a remnant of very ancient barbarism, preserved by the forms and regulations of a priesthood; and some have gone so far as to attribute the vestiges of color, which they could not fail to see, to the later barbarism of the middle ages. The advocates of this notion, and especially the friends of art, who belong to the Weimar school, still endeavour to maintain their ground.

On the other hand, the evidences of ancient Polychromy, which cannot be altogether refuted, have for some time past not been without their firm supporters. Of these, the most illustrious was Quatremère de Quincy, who more than twenty years ago, in his splendid work on the Jupiter of Olympia, first broke up this new ground, by an attempt to give a visible representation of the various application amongst the Greeks of the toreutic art, and to vindicate and defend it, as well as Polychromy applied to sculpture in general. But in reference to the subject before us, this work, comprehensive as it is, is of very limited application. Later writers followed his steps; new discoveries and researches continued to furnish positive and visible proofs to confirm and extend his views; and some carried them so far as to say, in direct contradiction to the former theory, that the plastic art, as exercised by the Greeks, presented to their contemporaries so perfect an imitation of nature, that it became even an illusion. Völkel in

* The science of the investigation and judgment in works of the imagination, whether in literature or the fine arts, according to the principles of sound philosophy, and the rules of logical deduction. Monsieur Couturier de Vienne, in his translation of Schlegel's Lectures on the History and Theory of the Fine Arts, 8vo. Paris, 1830, at page 9, gives the following definition of the word Æsthetics: "The theory of sensations and sentiments"; and states that æsthetical ideas are those which are the result of the imagination and of the senses, in opposition to those which arise from reasoning only. Baumgarten would appear to be the first who gave this name to this department of taste, when he wrote his work on Æsthetics. W. R. H.

particular, who could not before quite enter into the splendour and fulness of the Chryselephantine Jupiter at Olympia,* as represented by Phidias, now ventured distinctly to assert, that the Greeks, in the best period of their art, not only gave a complete coating of paint to their statues, with an appropriate variety of colors, but that they also superadded to them lights and shadows.† This view has also been taken by other writers.

The same was the case with the researches upon Greek architecture. Here also were compared the several discoveries of remains of color, which were found principally in the details; though at first, as in the new edition of Stuart's "Antiquities of Athens," in the "Antiquities of Attica," published by the Society of Dilettanti, &c., nothing more was done, than the simple statement of the fact. Hittorff first came forward with a complete system of Polychromic Architecture.‡ He had found, in his examination of the monuments in Sicily, a much more extensive application of color; he connected with those discoveries, what others had previously observed on the monuments of Magna Græcia, Etruria, Attica, and elsewhere, together with his own hypotheses; and out of these he framed a complete system, which was accepted with approbation, at least by some French connoisseurs.§ Herr Semper has very recently expressed himself in terms still more decisive,‖ and on the strength of his own researches in Greece, he assures us that he has discovered a complete coating of color upon all, even the most remarkable monuments of the age of Pericles; and he has announced shortly the publication of those monuments, restored according to one uniform system and with their proper colors. He has also, since his return from Greece, exhibited at Berlin, in different societies, a considerable portion of his restorations, which are certainly very ingenious, and which are said to have excited, at least amongst the younger portion of his countrymen, a degree of enthusiasm; the forms of Greek architecture now appear for the first time to become intelligible, and to present as a whole, a lively perception of the motive which gave birth to them. Indeed it would not have been easy, on the first fleeting impressions of their appear-

* On the great temple and statue of Jupiter at Olympia, p. 166, etc.

† L. Völkel's Archæological Remains, published by R. O. Muller, part I. p. 82.

‡ "De l'Architecture Polychrôme du Grecs, ou restitution complète du Temple d'Empédocles dans l'Acropolis de Sélinunte," in the "Annali dell' Instituto di Corrispondenza Archeologica," vol ii. p. 263, etc.

§ Compare "Séance publique de la Société libre des Beaux Arts," le 25 Decembre 1831, p. 20, etc.

‖ Preliminary Observations on the Painted Architecture and Sculpture of the Ancients.

ances, to have distinguished how the modes of feeling amongst the ancient Greeks, their habits, and the natural phenomena amongst which they lived, could have been brought into relation with those of the modern people of the north, who are so deficient in form and in color, but who lay claim to greater means for giving life and animation to the creations of their genius.

According to these notices then we see, that if Polychromy has by some been decidedly denied and rejected, it has by others, with equal perseverance, been accepted and appreciated. From the great importance however, which it possesses, for a right understanding of Greek art in general, and from the remarkable influence which this Greek art exercises, and must exercise,* upon the schools, in which it is now taught, an unprejudiced discussion of these opposite opinions seems to be called for. This is the object of the following pages. We shall merely place in juxta position, and examine, the notices to be gleaned from ancient authors upon the subject, and the researches of modern inquirers, in the hopes of obtaining from them a satisfactory result. We shall not completely carry out our review to the plastic art, as well as to architecture, although they are necessarily connected with, and serve to complete each other; but we shall allude to the polychromy of sculpture in those parts only, where it forms more immediately a component part of the monuments to which we shall have occasion to refer.

ARCHITECTURE.

1. Testimonies of ancient writers.

Pausanias, in his description of Athens, mentions amongst the courts of justice in that city two, which, from their colors, were respectively called "The Green," and "The Red;" denominations, which were preserved up to his time.† But if we know also, that all the ten courts of justice or tribunals, in Athens were marked both by the ten first letters of the alphabet and also by different colors; and that the application of those colors, as is evident from the geographer's words, was of very ancient date and had been introduced for those who were unable to read, serving as it did, equally with the letters of the alphabet, merely to distinguish one tribunal from another, we shall be inclined to agree with the different com-

* We shall not forget the Epigram on the scarf of Leucothea.

† Pausanias, lib. I. c. xxviii. 8.

mentators on the passage, in looking on these colors merely as a kind of ornament, a distinctive mark on the entrance into the tribunal, or immediately in front of it,*—an object of criticism, which is of less consequence to our inquiry. But as this last hypothesis has not yet been sufficiently made out, if we should prefer to abide by the former interpretation and consider the two buildings, one as green and the other as red, we must allow that this was a remarkable exception to the general practice, in order to distinguish these particular buildings from the rest. But on neither supposition should we be justified in concluding, as Hittorff† has done, from the words of Pausanias that this was a common usage indiscriminately applied to architecture in general, temples, as well as other buildings throughout Greece. Raoul Rochette‡ has already satisfactorily refuted this too easy conclusion.

Vitruvius, also, in the passage in which he describes the entablature, as derived from the early practice of constructing in wood, mentions the slabs, which afterwards assumed the form of triglyphs and which were nailed *in front of the transverse beams*, as having been painted with *blue wax*, cerâ cæruleâ.§ From this last expression, (not to enter further into this hypothesis of Vitruvius, or of his instructors, on the origin of the forms of architecture from wood work, or carpentry,) we might perhaps conclude that he had actually seen Doric monuments with blue triglyphs. But as he is speaking of a practice of ancient times, it would appear, that we should refer it, rather to very Archaic monuments, than to those of a period when the art was more developed; to those, for example, such as the Etruscan and the Sicilian, which lay more under his observation, than those of Hellas: a distinction the importance of which will hereafter receive more developement.

In another passage,‖ Vitruvius speaks of Peristyles, Exhedræ, and other open spaces, the walls of which were painted over with minium.** But as he had previously observed,†† that the excessive use of this expensive color had only been introduced in his own time, we cannot, from this cir-

* Compare Siebilis: Pausaniæ Græciæ descript. Adnott. ad., lib. I. c. xxviii. 8, (p. 104).—Akerblad: Sopra alcune laminette di Bronzo, &c. in the Atti dell' Academia Romana d'Archeologia, tom. I. part i. p. 46, etc.—Raoul Rochette: De la Peinture sur mur des Anciens, in the Journal des Savans, 1833, Juillet, p. 440.

† Annali dell' Instituto, etc. p. 266.

‡ See above.

§ Lib. IV. c. ii.

‖ Lib. VII. c. ix.

** Minium is strictly a deutoxide of lead, but that of commerce contains portions of sulphur chlorine and silica.—See Brande's Chemistry. W. R. H.

†† Lib. VII. c. v.

circumstance at least, draw any positive conclusion for a period so far back as when the architecture of the Greeks was at its zenith.

Pliny speaks of a temple of Minerva at Elis, in which the painter, Panœnus, brother of Phidias, had applied a layer or coating of stucco on the walls, in a solution of milk and *saffron*.* From this expression we might conclude that the walls were covered with a yellowish color, if this daubing employment could reasonably be attributed to such a distinguished artist. Böttiger explains it simply, by the supposition that this treatment was merely as a ground for pictures afterwards to be painted upon it.† But the whole passage is one of the many trite anecdotes of artists, in the collection of which Pliny so frequently indulged: the subject-matter with him was merely the smell of saffron, which was still sensible in his time, when the wall was rubbed with saliva. I know not how far one might venture to connect with this anecdote an observation of Plutarch, that certain monumental marbles in the neighbourhood of a temple of Diana Proseoa, on the coast of Euboea, presented also, when rubbed, the smell, and even the color of saffron.‡ These were of course white before they were so rubbed.

The above then are the detached, insulated passages, trifling indeed as they are, which we find in the ancients upon Polychromic Architecture. They have of course nothing to do with the painting of rooms. We shall however give one more reference, which seems to promise a more satisfactory result.

In describing the statue of Jupiter at Olympia, Pausanias mentions that the barrier, or breast work, which encompassed the statue, was decorated with paintings by Panænus, but that the part of it over against the door was a plain blue.§ (ἀλήλιπται κυανῷ μόνον.) A singular idea of the artist, who, with the rest of the work so enriched, should here so suddenly have broken off, to leave an empty space, and have covered the sides with valuable paintings.‖ We can in no other way understand the passage, as descriptive of a work of art, than by admitting with Völkel,** that the words "over against the door," (ἀπαντικρὺ τῶν θυρῶν,) are not to be taken to mean the entrance into the temple, which was at a considerable distance off, but the door of the opisthodomus, which was immediately behind the statue, and then we per-

* Plin. Nat. Hist. lib. XXXVI. c. xxiii.

† Ideas upon the Archæology of Painting, p. 244.

‡ Plut. Themistocl. 8. § Lib. V. c. xi. 2.

‖ Quatremère de Quincy thus represents the statue seated upon the throne, in the title page of his "Jupiter Olympien."

** Archæological Essays, p. 51.

ceive how the introduction of paintings at the back of the barrier, where few spectators could come, and there would be little light, would have been superfluous and useless. But if this part of the barrier was plain blue, we might fairly presume that the surrounding walls of the altar would have been in harmony with it; if these had been white, the wall of the barrier would also, it seems, have been the same. This conclusion, if it is not overstretched, gives us some determinate notion respecting the interior of a temple, which was one of the most remarkable in Greece.

The fact, that so few passages occur in the ancient writers, containing any allusion to the use of colors in architecture, is accounted for by the patrons and advocates of Polychromy, on the ground that there was no occasion whatever to instruct contemporaries in what was in universal use: and generally speaking, we may allow to such an argument its due weight. But what are we to say, if other passages are produced, which bear testimony directly adverse to Polychromy, at least to the extent which has of late times been given to it?

It has often been a subject of regret, that Pausanias, when he speaks of temples, gives us scarcely any information respecting their actual and real state. In reference to what is mainly interesting to us, we find only now and then a notice of the material of which they built: this, however, may perhaps lead us to some results. Besides several buildings which were made of bricks, baked or crude, (ὀπτῆς πλίνθου, ὠμῆς πλίνθου,*) he mentions the Poros-stone (ἐπιχωρίου πώρου, λίθου πωρίνου) in the temple of Jupiter at Olympia, and in the massive walls in the Altis at the same place, on which the treasuries were built.† Now it is evident that when either bricks, or the coarse Poros, were employed, the architect could not give to the walls of his building the required polish, nor sufficient sharpness to the members of the architecture, without covering them with a coating of stucco; and it is quite conformable to the progress of art in its general developement, that the great monuments thus furnished with a layer of stucco should have preserved, as they did in form so also in color, a due relation to the splendid edifices, which were constructed of white marble. What therefore we shall be able to demonstrate respecting these last, will serve more or less to explain the colors of the former.

Pausanias indeed mentions few monuments of a large size, as constructed of *marble*, under its general appellation of *white stone* (λίθου λευκοῦ); for example,

* Lib. II. c. xviii. 3; ib. c. xxvii. 7; lib. V. c. v. 4; lib. X. c. iv. 3; ib. c. xxxv. 5.
† Lib. V. c. x. 2: lib. VI. c. xix. 1.

the Stadium of Herodes Atticus at Athens; the splendid roof of the Propylæa, which led into the Athenian Acropolis; the Theatre and Stadium at the Isthmus; the Tholus built by Polycletus at Epidaurus; the Theatre at Sparta; and the Temple of Bacchus, at Myus in Asia Minor.* The Greek term for marble, λίθος λευκὸς, allows of a double meaning: it may be understood of the stone, the fracture of which is white; or when the author is speaking of particular buildings, it may refer generally to their external appearance. Other authors also, particularly Strabo,† speak of many temples built of "white stone." It would seem very extraordinary that this expression should have been so generally made use of, if the *whiteness* of the stone itself did not strike the eye. Moreover, the marble may have been employed in the theatres and stadia above mentioned, solely on account of its peculiar splendour and richness, and we must on no account imagine to ourselves that these monuments were painted over. Pausanias further speaks of a shell marble, (λίθος κογχίτης) which was quarried near Megara,‡ and very much in use there. This stone was remarkable for its peculiar whiteness. Why make mention of this circumstance, if the natural property of the stone itself never came under observation? Finally, he mentions two buildings of *Pentelic marble,* (a stone which, it is evident, must have ranked amongst "the white"); one of them, the temple at Gortys in Arcadia; and the other, the Stadium of Herodes Atticus at Delphi.§ And why should they have gone to the great expense of conveying this stone so far from Attica, if its own peculiar property was to be concealed by a coating of color? The same will apply to other edifices, for which costly materials were brought from a distance, as, for example, the front of the temple at Delphi, which, according to Herodotus, ‖ was built by the Alcmæonidæ, during the reign of Pisistratus at Athens, of *Parian marble;* although that family had only undertaken to construct the whole building of the more ordinary Poros stone: and if the front was white to the eye, the stucco laid upon the Poros must have been white also.

Here too we must take notice of a small temple at the port of Anticyra in Phocis, of which we are told by Pausanias, that it was built λογάσιν λίθοις, (or the opus incertum of the Romans,) probably therefore in the Cyclopian style, like the small temple at Rhamnus,** and that its interior was covered

* Lib. I. c. xix. 7; ib. c. xxii. 4; lib. II. c. i. 7; ib. c. xxvii. 3.; lib. III. c. xiv. 1; lib. VII. c. ii. 7.

† Lib. XII. c. v. 3; lib. XIII. c. i. 16; ib. c. iii. 5; lib. XIV. c. ii. 23, &c.

‡ Lib. I. c. xliv. 9.

§ Lib. VIII. c. xli. 5; lib. X. c. xxxiii. 2.

‖ Herod. lib. V. 62.

** See the unedited Antiquities of Attica, c. vii.

with stucco.* The interior therefore may have been decorated with colors, but the exterior, as is evident from the contrast implied, must have exhibited the natural color of the stone.

Now if, when we see so many instances of the materials, used in the erection of the most remarkable buildings, being accurately noticed, and when these materials sometimes take their name from their own white color, the omission of all mention of a second coloring appears extraordinary, the same silence in another instance will be still more difficult to explain. We know the predilection, which arose under the Roman empire, for gay and bright colored marbles. Pliny complains bitterly of the foolish vanity of such taste. "*We have begun,*" he continues, "*even to paint stone. This was invented during the reign of Claudius.* Again, under the rule of Nero, we have endeavoured to produce spots, where they did not exist before, by a coating of lime, (*crustis inserendo,*) and to give a gaudy variety to that which is of a single color, so that the marble of Numidia assumes an appearance of ovules, and that of Synnada is distinguished by its purple marks."† Now can we, with any probability, suppose, that the Greek mode of painting marble temples, if practised for five hundred years, could have been so totally unknown to Pliny, that he should have attributed the commencement of the painting of marble to the reign of Claudius? Seneca also agrees with Pliny, in censuring these new usages.‡

Nor should we overlook the circumstance, that in the paintings on the fictile vases, whenever the architecture of a temple is represented, this is usually painted white, whilst the figures, as is well known, are red upon a black ground. It is only the mouldings and necking of the (Ionic) columns, which generally present some yellow lines. Why should they have here selected precisely a white color, if the buildings in existence were party-colored?

All doubts, however, which might remain after the foregoing observations, must be removed by an anecdote in Herodotus. This author—a contemporary of Pericles, who flourished therefore in the most brilliant period of Greek art—reports an oracle, which the Pythia delivered to the inhabitants of the island of Siphnos, and which began thus:

> When the Prytaneia in Siphnos shall be white,
> When the Agora shall be white, &c.

* Lib. X. c. xxxvi. 4. † Lib. XXXV. c. i.

‡ Ep. 86. These passages of Pliny and Seneca, appear rather to refer to mosaics, and to the insertion of various colored pieces, figured or otherwise, in the principal slabs. Tr.

"But the Agora and Prytaneion of the Siphnians," he continues, "were at this time (that is at the fulfilment of the oracle) built (or cased) with *Parian stone.*"* What makes this passage so important for our purpose, is not the insulated information we get from it respecting the white edifices of the Siphnians, but the reason for which they were white; a reason, which must have been held valid by the whole assembly of the Greeks, when the author read to them his history at the Olympian Games, and afterwards at the feast of the Panathenœa in Athens. We may thence draw a positive inference:—*That what was constructed in the brilliant period of Greek art of Parian marble, and, as a necessary consequence also, of any and every white marble, particularly as at Athens of Pentelic marble, was allowed to preserve essentially its external white appearance.* The testimonies bearing upon this question, which have been previously adduced, were only brought forward that this passage in Herodotus might not appear too insulated, and perhaps even its genuineness be disputed.

The opinion, therefore, of those individuals, who would extend the Polychromic system, so as to embrace all the architectural members even of the purest Hellenic monuments, is unsupported by any written testimonies, and the most decisive testimonies are against it. But, before we proceed to enquire what remains of color *do* actually present themselves upon antient monuments, it will be well to take into consideration the subject of metallic decoration, on the application of which to the splendid edifices of Greece various accounts have been handed down to us.

We shall pass over, as too remote from our subject, the notices in Homer and others, of the extensive and prodigal use of metallic ornaments in the princely houses of the heroic age. We shall equally disregard insulated examples of a later time, as the brazen or copper-sheeted temple of Minerva Chalcioicos at Sparta,† which, being particular exceptions, prove nothing for the general practice. But there did exist several temples, of which we know that either the architrave or frieze was decorated with gilded shields, which generally had been dedicated by successful conquerors from the spoils of victory. The twenty-one shields which adorned the Temple of Jupiter at Olympia, as the votive offering of Mummius, are well known.‡

* Αλλ' ὅιαν ἐν Σιφνῳ Πρυτανήϊα λευκὰ γένηται,
Λευκοφρύο τ'ἀγορή, κ. τ. λ.
Τοῖσι δέ Σιφνίοισι τότε ἦν ἡ ἀγορὴ καὶ τό Πρυτανήϊον Παρίῳ λίθῳ ἠσκημένα.—Herod. III. 57.

† Pausanias, lib. III. c. xvii. 3. Compare Myer's History of the Plastic Art amongst the Greeks, book II. p. 14, etc.

‡ Pausan. lib. V. c. x. 2.

The Temple of Apollo at Delphi was decorated in the same manner by the Athenians after the victory at Marathon, and by the Ætolians after that which they gained over the Gauls.* On the Parthenon at Athens are still visible the holes for clamps in the architrave, and circular stains upon the marble, about three feet and a half in diameter, which evidently indicate the same practice.† On the eastern front of this temple a shield was suspended under each metope, and small holes on the architrave under the triglyphs indicate probably that prominent letters were there inserted, forming an inscription between the shields. On the western front the holes are larger, but they are only observed above each column, evidently for the same object; and on the northern and southern sides have been discovered a few smaller holes also immediately above each column, accompanied too with clamp-holes on some other parts of the architrave, which probably served for the suspension of trophies of the same or some other description.‡ It is not unlikely, that these are the vestiges of those Persian spoils, which Alexander the Great transmitted to this temple after the battle of the Graneicus.§

We must consequently consider this decoration of gilded shields as quite independent of the external appearance of Greek architecture. The architects could not properly erect their buildings purposely for such accessory ornaments, nor could they prepare themselves beforehand with any regular or systematic arrangement of votive offerings. Pausanias expressly says, in speaking of the Gymnasium at Elis, which was similarly decorated, that in this particular case the shields had been fabricated merely for ornament—not, as in other instances, for service in war.‖ We must consider in the same light, that is as accessory decorations, the gratings (probably also gilded) which ran between the columns and the antæ, and closed the porticoes of the temples, for the security of the valuable votive offerings, which were preserved within. Vestiges of the clamp-holes of these have also been found in the porticoes of the Parthenon, and in that of the temple of Theseus at Athens, in the pronaos of the larger temple at Rhamnus, and in other places.** These examples, however, at all events prove the remarkable predilection of the Greeks to embellish their architecture with gilded metallic ornaments. The many examples mentioned by Pausanias, of gilded

* Pausan. lib. X. c. xix. 3.

† See Dodwell's Classical and Topographical Tour through Greece.

‡ Stuart and Revett's Antiquities of Athens, part II. c. i.

§ Arrian, lib. I. c. xvi. "Three hundred complete suits of armour."

‖ Lib. VI. c. xxiii. 5.

** See Antiquities of Athens, and the inedited Antiquities of Attica.

statues, vases, and other antifixa, on the apices and angles of the pediments of the temples, show this most decidedly. Marks have also been found on the angles of the pediments of the Parthenon, which make it probable that the decorations on these spots were of bronze.* And the reliefs on the frieze of the Erectheum at Athens, which are mentioned in the well-known inscription, appear likewise to have been of metal, as the frieze is itself quite smooth and even, and nothing is now visible but the clamp holes.†

We read of a similar enrichment by metallic decoration, in the description of the great Ship (only to be used upon the Nile) constructed by Ptolemy Philopator, (towards the end of the third century before our Æra) a floating palace, as it was called. The Corinthian capitals of the pillars of the principal saloon were of gold and ivory—probably the bases were of gold, and the leaves of ivory; the frieze was of gold, with figures in relief cut in ivory.‡ On the choragic monument of Lysicrates in Athens there seems to have been a circular band of bronze in each of the grooves under the capitals of the Corinthian half columns, though the small palm leaves which form the lower member of the capitals are so sharply cut off, that one is inclined to attribute a style of working so devoid of any proper motive, to a restoration but ill corresponding to the true spirit of Greek art.§ Finally, on the walls of the temple of Jupiter at Cizycus, a thin gold thread indicated, as a special ornament, the joints of the stones.‖

If then we wish to present to ourselves the impression of the most remarkable buildings in the flourishing period of Greece Proper, we must conceive their effect to have been produced by a rich white marble in its own natural brilliancy: and, when the materials employed were of a baser description, by a coating of stucco, which in its outward appearance did not much differ from that marble; these were then combined with appropriate ornaments, and resplendent with gold.**

* Antiquities of Athens, part II. c. i. See also the Erectheion of Athens, by H. W. Inwood, tab. XVII. p. 121.

† Antiquities of Athens, c. ii. The author subsequently mentions some other ornaments belonging to this building, which were probably also metallic.

‡ Athenæus V. p. 204.

§ Antiquities of Athens.

‖ Plin. Nat. Hist. lib. XXXVI. c. xv.

** In a further part of this essay, the author considers how far the sculptures on the pediments and on the friezes were made to harmonize with this construction.

2. REMAINS OF COLOR ON ANCIENT MONUMENTS.

Remarkable remains of colored architecture are preserved to us even from the earliest times of Greece. The well known relief of the two Lions, which closes the triangular space over the "Gate of the Lions" at Mycenæ, consists of a greenish marble, which has been compared to the green basalt of Egypt.* The remarkable half-columns, which were at the two sides of the entrance into "The Treasury of Atreus" at the same place, are of the same stone. The fragments of the decorations on both sides of the same entrance, are of green, red, and white stone.† We must not however from these remains draw any conclusion for the subsequent periods of Greek art, as the *Dorismus* or Doric institutions, afterwards introduced, occasioned essential changes in all the habits and forms of life amongst the Greeks, as well as in their arts. It is nevertheless to be observed, that colored architectural forms were here produced in the simplest and most natural manner, namely, by different colored stones.

We shall now proceed at once to the most perfect buildings of Greek art, remains of which still exist, that is, those of Attica. These buildings, especially those in Athens itself, are for the most part constructed of the beautiful white marble quarried in Attica; and, according to the researches and descriptions of travellers, evident traces of original decoration by the application of colors, have been found on the entablatures and fasciæ of the most remarkable amongst these edifices. We shall consider them separately.

3. MONUMENTS OF ATTICA.

The Temple of Theseus.‡ The various accounts which have reached us on the vestiges of color preserved upon this building, relate chiefly to the

* Dodwell: Alcuni bassirilievi della Grecia, p. 2; and his Classic. and Topogr. Tour, etc. vol. II. p. 239.

† Ib. p. 231. Donaldson in the Supplement to Stuart's Antiquities of Athens, vol. V. Comp. K. O. Müller. The Dorians, lib. II. p. 256.

‡ The following memoranda upon this monument are from the MS. observations taken by T. L Donaldson, Hon. Sec. in the year 1820. "Stuart's drawings of this temple are the most complete of any in his work, and very few remarks can be offered in addition. The ground of

decoration of the entablature within the peristyle, where the friezes are embellished with reliefs. Besides the remains of color on the figures of the frieze, the ground also, against which the figures rest, has been painted blue.* Underneath a projecting fascia with the painted mæander rests upon an ogee ornament having heart-shaped leaves, and a string of beads and pearls. Above the relief projects also a broader fascia, on which a rich mæander has likewise been painted; both these mæanders, it seems, were red; above this last mæander, and separated from it by a bird's beak moulding decorated with leaves, was another broad fascia between the beams of the roof, with a beautifully twisted palm-leaf ornament; upon this was an ovolo painted with eggs, and finally over this last the soffits of the roof.† Traces of a dark color have been found on the ground of these soffits, on which stars were painted in a lighter colour.‡ Red, blue, green, and some doubtful vestiges of gilding, form, according to the latest accounts, the different colors, which alternate in these decorations.§ Under the neck of one of the antæ of the porticoes, (facing the columns in antis) Semper found a piece of the blue paint; whence he concludes, that the whole of the exterior of the cella was painted blue. Schaubert, on the other hand, says, that he found on this spot yellow instead of blue.‖ This circumstance, as also the red architrave, mentioned by both these writers, and the red pillars

the caissons of the ceilings was blue, with a gilt star. All the mouldings and small fasciæ within the colonnades were painted with an ornament. The soffit of the outside cornice at the N. W. angle had also a painted ornament, probably a honeysuckle, the lines of which still remain in part, although it is impossible to determine the whole form. A thin coating of some substance is on all the columns and on the face of all the interior architraves and friezes; and I am inclined to think that the whole edifice was once covered either with a stucco or a thin coat of paint. The soffits of the mutules were painted blue, and I have some of its color. All the fasciæ of the exterior architrave and the bed of the cornice were decorated with painting, but the weather has acted upon it to such a degree as to erase the coating in great part; still, however, it is distinguishable, yet no form can be traced. The interior and exterior faces of the walls of the cella are worked with a point, evidently for the purpose of receiving a coat of plaister or paint. The holes for the railing, which divided the opisthodom from the posticus, may be seen in the columns and antæ, as also a chasing cut in the columns and antæ at the base to receive a plinth, as at the Parthenon.

The diminution of the column ends at a distance of about 2 inches above the necking, and the profile then commences to take the diverging direction of the capital. Stuart has not shewn the sensible difference of dimensions existing between the outer columns of the peristyle and the inner ones of the posticus."

* Dodwell, vol. i. p. 364. Semper, p. 48. † Antiquities of Athens.

‡ Chandler's Travels, vol. ii. c. 14. Museum, Blätter für bildende Kunst, 1833, No. 32. Notices from Greece, by Schaubert, compiled by F. v. Quast, p. 253.

§ Semper. ‖ Idem.

described by Semper, will be considered hereafter. The mutules of the exterior entablature seem, when viewed from below, with the exception of the guttæ, to have been painted blue,* as well as the ground of the metopes forming the exterior frieze.†

The Parthenon. As the remains of this building could not, till very lately, be examined with the same facility as the temple of Theseus, we have not such detailed accounts of the remains of its colored decorations; but, generally, the painting of the entablature within the peristyle, and on the capitals of the antæ, is described in a similar manner to that of the other temple: those members, which are flat and in direct lines, have the mæander and palm-leaf ornaments; those, which present an ovolo profile, have the egg and tongue. Besides the painting on some members of the cornice of the outer entablature, the two fasciæ, above and below the frieze, were specially painted with a mæander, and the small fascia below the triglyphs with elegant palm leaves.‡ The vestiges of the color of these ornaments are of a dark brownish red.§ But the editor of the new edition of the "Antiquities of Athens"‖ has added, that here and there, by a favorable reflection of the light of the sun, traces of actual gilding may be perceived upon the mutules, and this statement has led to the conjecture, that the colors above described were only the ground of the gilding, where this has disappeared. Even if we reject this supposition, as not yet sufficiently substantiated, we must on no account lose sight of it in the review we would take of the entire system of these painted ornaments. The mouldings of the inclined cornices of the pediments were painted with slight palm-leaf ornaments.** The ground of the frieze above the interior of the peristyle, which contains the reliefs of the Panathenaic procession, was blue.††

The Propylæa of the Acropolis. Here also we can only refer distinctly to the painting of the inner entablature; a broad fascia with a mæander, surmounted by a bird's beak moulding, and resting upon an ogee, both painted with different leaves: the same applies to the bird's beak member in the capitals of the antæ. Here also, where the original color (the outlines for

* Antiquities of Athens, &c. † Idem, and Dodwell.

‡ Bröndsted, ut supra. The following remarkable passage occurs in Wood's Letters of an Architect, 4to. London, 1828, vol. ii. p. 252,—"You may see in several places marks of ancient ornamental painting, and in some instances of painting of *two different styles and dates*, one of which has been over (or covered) the other."

§ Antiquities of Athens. ‖ Idem.

** See Vulliamy's Examples of Ornamental Sculpture in Architecture.

†† Millin, Monumens Ant. Ined. tom. ii. p. 48.

which are, as usual, carved upon the marble,) appears a rich dark red, some have believed they saw the ground of a gilding which has disappeared.* The corona moulding of the pediment is decorated with the egg and dart. On the Ionic capitals of the interior range of columns, the cushions, as seen from the side, were painted with scales, and tendrils of the acanthus. These also, according to Schauberts' design, seem to have had a necking like the pillars of the Erectheum, not however sculptured, but painted.†

On the north side of the Propylæa, the different members are painted, like those in the interior of the principal building.

The Erectheum, (Temple of Minerva Polias). In respect to this most elegant and graceful building, we have no definite notices of any colored decoration, as still existing. Inwood has published the fragment of a soffit, which was surrounded with a painted mæander.‡ In the lace-worked torus which, in the capitals of this temple, is between the channel of the volutes and the echinus, colored stones or glass have been set in some of the squares, which alternated red, blue and yellow.§ The remains of metal nails, in the sinkings between the channels, in the deepest centre of the volutes, as well as on the sides of the capitals, prove that some additional decorations were originally applied there.‖ Other beautiful fragments published by Inwood, show that an ornament in the centre, or eye of the volute in the Ionic capital, was not unusual, in the best period of Athenian art. One of these capitals has a pointed hole in the centre of the eye, evidently for inserting some peculiar ornament; in two others, the eyes are decorated with elegant rosettes with eight petals.** On the upper fascia of the architrave of the portico of the Caryatidæ, round holes have been drilled; on one of these, the lines evidently indicate some special and appropriate ornament.†† We ought also to mention the columns of green marble, which have been found in the interior of the Erectheum, one of which has been for thirty years in the University Library at Cambridge;‡‡ the other was recently discovered by Semper, during an excavation.§§ We

* Antiquities of Athens, and Dodwell.

† Museum Blätter für bildende Kunst, 1833, No. 32.

‡ The Erectheion of Athens, by H. W. Inwood, Pl. V.

§ Antiquities of Athens. Stakelberg on the Temple of Apollo at Bassæ in Arcadia, p. 34.

‖ Antiquities of Athens.

** Erectheion of Athens, p. 23, 25, 28. A pointed hole is also drilled into the eye of the volutes of the Ionic capitals in the Temple of Minerva Polias at Priene in Asia Minor.

†† Antiquities of Athens. ‡‡ Clarke's Greek Marbles, &c. 1809.

§§ See Semper's Preliminary Observations on Painted Architecture and Sculpture, p. 12.

regret that we have no more accurate account or drawings of the form of these columns to verify our doubts, whether they may not belong to some later alteration in the middle ages. As regards the Parthenon, at least, we must admit, that the fragments of columns of red porphyry and green marble, which Dodwell discovered in the interior,* should be referred to the transformation of the building into a Christian church, of which Tavernier says, that in the interior it was supported by very beautiful pillars of porphyry and black marble.† The last expression ought not to be any objection, coming from a traveller, who is not one of the most accurate in treating of collateral details.‡

The Ionic Temple on the Ilissus. In this building, the uppermost of the three fasciæ of the architrave was painted with a remarkably beautiful, though somewhat formal, palm-leaf ornament.§

The Choragic Monument of Lysicrates at Athens, exhibits also various remains of painting, particularly on the fillets of the cornice, ranged in tiers one above the other, the leaves of which were alternately colored in different greens and reds. Traces of color exist also on one of the interior cornices of the *Tower of the Winds.*‖

The Exterior Propylæa of the Temple of Ceres at Eleusis. Remains of color are found on the soffits of the ceiling of this copy of the Propylæa of Athens. They contain on their upper surface green and red stars, (without any darker ground,) and egg ornaments in similar colors on the torus. The starred tiles of this building have also been originally painted.** Outlines of stars have likewise been discovered in the soffits of the ceiling of the *interior Propylæa.*††

The larger Temple at Rhamnus. Here also have been preserved very rich vestiges of colored embellishment. As in the Temple of Theseus at Athens, there are broad bands along the cornice of the wall of the cella in the peristyle, the lowest of which was adorned with a Mæander, the upper

* Dodwell, vol. i. p. 331.

† Voyage de Perse, lib. III. It is well known, that Stuart took the marks of these columns of the Christian church built in the middle ages, for vestiges of the ancient hypethral arrangement; but Cockerell has recently discovered the genuine marks of the antique columns. There were only sixteen of them, and of large proportions, as the Hypethral System required. Compare "Antiquities of Athens," and Bröndsted.

‡ Possibly the fragments mentioned by Dodwell may refer to the pillars of jasper, which separated the choir from the nave of the church, and to the porphyry pillars of the tabernacle on the altar, which Wheler speaks of, vol. II. c. ii. p. 325.

§ Antiquities of Athens.

‖ Museum, at supra.

** Inedited Antiquities of Attica, c. ii.

†† Idem. c. iii.

one with a palm-leaf ornament; but over each of these are bird's-beak mouldings, also painted with leaves. There are also remains of color on the soffits of the ceiling; the ground of which, it seems, was blue, and the stars gold. The outlines of that leaf ornament are also visible on the capitals of the Antæ, which present an exact imitation of those of the Parthenon. The string-courses of the pediment, which are here also continued along the long sides of the temple, had likewise a colored decoration, which has protected the marble from the influence of the air, so that it is still seen in slight relief.*

From the preceding observations, it is evident that the traces of color which are found on Athenian monuments, the most beautiful productions of Grecian art, were in truth merely decorative of the several members of the architecture. We have, however, already shown, that some writers speak of the traces of an ancient coating on the architraves, on the external walls of the cella, and on the columns of the Temple of Theseus: Mr. Semper indeed positively asserts, that the monuments were completely covered over with color, so that, even on the places which were intended to be white, the white marble itself was by no means exhibited to view; but here also a white color was laid on.† This assertion, which is in decided contradiction with the recorded testimonies of the ancients, claims a more critical examination.

"The color, for instance, which the Pentelic marble on the monuments of Athens exhibits at the present day, assumes the appearance, in masses of considerable extent, of a beautiful almost reddish gold yellow, and in the angles and corners, of a darkish black. This hue is not to be considered, as hitherto has been the case, as the change produced by the lapse of time on the surface of the stone, but as the remains of an ancient coating of color; and by a close examination, spot by spot, the original colors may still be discovered, under the crust, preserved quite fresh." This last observation is perfectly just, in respect to the single architectural members above mentioned; but the general position has not been confirmed by the evidence of other travellers. Thus Dodwell‡ describes in detail the different gradations of color, in which the Parthenon appeared in his time:—"The western front had an ochrous color; the eastern the same, though some parts of the columns were black, which he ascribes to the smoke of some neighbouring cottages; the side to the south is the lightest, and in

* Inedited Antiquities of Attica, c. vi.

† Bröndsted had hinted at this opinion, though rather doubtfully, some years before. Vol. ii. p. 145.

‡ Vol. i. p. 344.

great part retains the original whiteness of the stone; but in all Athenian buildings, the south side is the most protected from the influence of the weather:" Why then should it be just on this side that the color should have faded more than on the east and west sides? We are farther told, that the marks of the shields which were on the architrave of the Parthenon, have been rendered the more apparent from the round surfaces having been less penetrated by the yellowish red tinting of the marble, above alluded to, in consequence of the shields themselves having, during several centuries, protected the stone from the action of the air.* But according to Mr. Semper's theory, the appearances ought to have been directly the reverse, and the spots on the architrave, which were under the shields, ought to have preserved in greater purity the coloring laid upon them.

It is also said, that "this presumed crust of color would have had the appearance of a strong glaze or enamel, and would have been of considerable thickness; indeed the thickness and prominence of this coating would require that the whole monument should have been covered with it, as, if this had not been the case, the color at the edges would very soon have pealed off." But neither the justness of this observation, nor the conclusion to which it leads, are confirmed by the accounts of other travellers. On the above mentioned temple at Rhamnus and on other monuments, we find on the contrary along side of the ornaments, which have been relieved by color, the stone worn by the action of the air or earth, whilst the parts once colored, or on which the color still remains, are uninjured.† The same appearances have been repeated on statues, which have been partially protected with encaustic colors.

It has also been already observed by K. O. Müller, in opposition to this theory of painting upon marble, that, according to the well known architectural inscription relating to the Erectheum, it was the custom to give an entire polish to the surface of the walls, gradually as they were raised from the stone pavement; but this polishing would have been quite useless, if their lustre was to be destroyed by a layer of color.‡ In reference to the Erectheum, it is more important for our purpose, that the frieze was constructed of grey Eleusinian stone, and was covered with a coating of stucco. This part then (in opposition to the whole of the rest of the

* Antiquities of Athens, part II. c. i. obs. 75. † Antiquities of Attica, c. vi. obs. 5.
‡ Gottingisher gelehrter Anzeiger, 1834. August, St. 140, p. 390, etc.

building,) appears calculated for a coloring, which, as will be seen hereafter, is generally to be presumed for the friezes.*

Finally, it is evident how little certainty there can be in hypotheses of one definite color having been applied to the larger surfaces, from the fact above adverted to, that Semper describes the walls of the cella of the Temple of the Theseus, as having been colored blue, and Schaubert says that they were red.

Until we shall have obtained from chemists a decided and formal opinion, that the gold tint on the Athenian monuments is in fact a relic of a real layer of color,—which we strongly doubt will ever be the case,—we cannot assent to the presumed theory. With this also fall to the ground the conjectures which have been hazarded, to account for the Greeks having selected marble, especially for those splendid buildings which some presume to have been painted with a variety of colors, namely, because it could be worked with greater precision; and that it did not require, as other stones did, a superficial layer of stucco, and the colours, which were laid on, became more brilliant, more transparent, and more durable. Still less tenable is the conclusion, that because the Greeks set a great value on costliness of materials, that which was invisible must necessarily have corresponded in keeping with the splendor, which the external surface exhibited. This admission does not seem to be very conformable to the nature of man: besides the contrary seems rather to result from the anecdote, to which Semper alludes in support of his views, namely, that Phidias preferred marble to ivory for the statue of Minerva in the Parthenon, and that the Athenians preferred the ivory, as more costly.† The ivory was not to be inserted into the statue, nor was the whole mass of the statue to be made of that material: it was only applied as a thin coating or layer, on a ground of some other material. But if a white marble temple is at once to be pronounced an ugly object, all we can say is, that it is a matter of taste.

Accordingly we can only adopt those accounts, which speak of *the painting of single details* on the buildings of Athens. As to what concerns the genuineness of this painting and its being contemporary with the construction of the monuments, we repeat, with approbation, the following words

* The supposition in the Antiquities of Athens, part II. c. ii. obs. 41, in reference to the application of the Eleusinian stone, cannot be defended. We cannot suppose that they first attempted to use it instead of a more costly marble, and that they afterwards covered it with a white marble-like stucco, to correct its dingy look. They must have been previously aware of the effect it would have.

† Valerius Maximus, lib I. c. 1. Extern. Exempl.

of Semper: "that the painted decorations on the Greek monuments are in the most perfect harmony of character and execution with the sculptures, and generally with the *ensemble:* and that it was only in the best period of Athenian art, that forms of such excellent, accurate and delicate design could have been produced.*

4. SYSTEM OF POLYCHROMY.

From the observations contained in the preceding pages, we are enabled to form a judgment of the various modes, in which Greek architecture was made to display its beauties, according to the various races, communities, and times: and how it attained its highest eminence in the buildings of Attica of the time of Pericles. This view gives us also the conviction, that amidst such a variety of forms, the law of colors, which is in itself so much more variable, must have been subjected to a still greater change. And particularly, unless we consider color as something totally indifferent and accidental, the expression of greater energy and force in the monuments of the severe style must have displayed itself also in stronger contrasts of color; where also an unmeaning half barbarous composition was produced, or where in later times the *motive* was misunderstood and a greater play of forms came into practice, there will be found a more arbitrary use of color: and finally, we must of necessity presuppose a greater purity and absence from either extreme, in this respect as well as in others, on the monuments of Attica. We must therefore have regard to the colored remains on the monuments of other countries with the greatest caution, and only in reference to general principles, if we wish to give a clear idea of a system of Polychromy, as it may have existed in the most illustrious developement of Greek architecture. It is unnecessary to say more on the erroneous results, to which a different mode of reasoning would lead us.†

In general words, the principle above laid down brings us to this conclusion, that if no others, yet certainly the white marble buildings erected in the flourishing time of Greece,—that is the greater proportion of those of

* Semper, ib. 19. Kugler next proceeds to examine the various evidences relating to this subject, upon the monuments in other parts of Greece and in Sicily, the details of which would render this paper unnecessarily long.

† It is upon this last principle that Hittorff proceeds, in his restoration of the Temple of Empedocles, (Annali dell' Inst. di Corresp. Archeol. II. p. 263, etc.) producing an occasional authority for each single detail, and thus conceiving himself authorized to construct a whole system.

Attica,—exhibited, in their principal parts, the material of which they were built in its own proper color; that painting therefore is only to be referred to the subordinate details. We shall now proceed to consider the different orders in reference to this restriction.

In the *Doric* order, two distinct forms immediately present themselves, which from their nature were susceptible of painting, and which are not to be understood without it. These are the metopes of the frieze, and that overhanging member of the cornice which is immediately above the mutules.

The metopes, which are peculiarly fitted to receive some sculptured ornament, properly represent open spaces. But as the necessarily compact connection of the entablature required a massive filling up of these spaces, they were faced with slabs, on which that sculptured ornament in relief was represented. The ground therefore of this relief must always be marked by a darker color, in order to give sufficient importance, both to the triglyphs, the proper supports of the cornice, and to the reliefs themselves. And when there were no reliefs, we must equally take for granted a darker color in the metopes, whose plain surface was doubtless, in that case, broken by a subdued decoration. Doric friezes, the metopes of which, as so often happens in modern buildings, have no decoration, either of relief or color, have not only a heavy appearance, but the form of the adjoining triglyphs is absolutely insignificant. We have no satisfactory account respecting the color of the metopes on the monuments of Attica, but we have very strong grounds for supposing them to have been painted blue: as for example, the analogy of the interior frieze of these buildings, the figures on which were relieved by a blue ground: and the tympanum of the pediment of the temple of Ægina behind the statues, was, according to all concurrent testimonies, painted blue. We do indeed find remains of red on the metopes of the temples in Sicily, but this can only be considered as a special peculiarity of that country.*

The overhanging member of the cornice above the mutules has no independent motive of its own: its profile expresses nothing of the kind, no peculiar meaning. But many remains of colors, and slightly carved outlines convince us, that this member was always made to produce a certain plastic effect, and that it was painted with a range of leaves, which consequently have a slight inclination forward, and appear as the graceful supporters of

* Bröndsted (book ii. p. 147,) assumes a red color for the metopes of the Parthenon, on the ground of evidence from ancient monuments generally; whereas he seems only to have had in his mind those of Sicily.

an overlying slab. It is also evident, from the remains of colors, that these leaves were marked not by mere outlines, but by actual painting.

If now we find two different members of the architecture designedly relieved by the use of color, we must necessarily take for granted, that they were accompanied by a more extensive system of coloring, as otherwise they would have had the effect of detached broken spots: and here we are assisted by the peculiar character of various details. Those members, for example, which present a strong profile, particularly when they are continued in long lines, do not at once express their peculiar motive; the eye does not observe so much the line of the profile, as a kind of play of light and shade, and even this is only perceptible under a favorable light; in order, therefore, to make the profile line distinctly visible to the eye, it was provided with a colored decoration, by which the principal lines are repeated, and the remainder has the appearance of being freely and carefully sculptured. These are the beads of the astragals, the eggs of the ovolo, and the heart-shaped leaves of the ogee, on all of which remains of colors are partially preserved, and which, by this treatment, are severally brought into harmony with the bird's-beak mouldings decorated with leaves. The sculptured representation of these ornaments, which we observe on the contemporary Ionic temples, and still more frequently on those of a later period, is an additional confirmation of the system of painted members, which we have above described.*

A similar law of colored decoration is partially visible on the string-courses running along the whole length of the building, although here the profile is more distinct, and the decoration must be looked upon as something more than an arbitrary addition; this is the mæander, the form of which is composed of rectangular broken lines, like the profile of the course itself. These courses however are sometimes painted with rows of palmette, which compose the most elegant decoration, and very generally too the upper corona of the several masses; and in another situation, that is, on the string-courses, they appear as the corona or crowning moulding of the whole structure.

The very limited number of accurate notices,† which we have upon the

* Some have looked for *a special symbolic meaning, handed down by tradition,* in these ornaments of the various members, but the eye knows nothing of such tradition; it only feels the beauty of forms, and acknowledges no other law than that which rests upon *them,* and justifies their existence.

† The reader is referred for the most recent information upon this subject generally, to the following work—Mittheilungen über alt und Neu Athen von A. F. von Quast, Berlin 1834, already quoted, p. 86, note ‡, and which work forms the ground of an ably written article in the Foreign Quarterly Review for October 1836, published as this sheet was passing through the Press.

subject, makes it, upon the whole, extremely difficult, if not impossible, to define with precision the colors with which these members were painted, whether as regards the ground color itself, or the ornaments laid upon it: and the more so, as we are not justified in referring single facts collected from the temple of Ægina, a building of Archaïc severity, to the monuments of Attica: such as the red string-course above the architrave, the blue fillets with the guttæ, and the red walls of the cella. This kind of restoration we leave to the discretion of the artist. But if we reflect how frequently gilded metallic decorations,—shields, for example, on the architrave, and sculptured figures on the acroteria, were added to the external architectural members; if we bear in bind the extensive usage, in Greek sculpture, of a white material in combination with gold, we must admit that gold was particularly prevalent in the accessorial painted decorations. The conjectures which have been frequently expressed, of the vestiges of a red color belonging to the remains of ancient gilding, agree with this conclusion.

We may therefore, in accordance with the preceding, sum up the general arrangement of Greek architectural embellishments in the following manner:—

The pillars, whose unity was not destroyed by the different members of which they were composed, form a perfectly white mass. It would be difficult to decide whether the echinus was decorated with eggs; its form is so significant and remarkable, at the same time its diameter so small, in proportion to the whole extent of the building, that it cannot be placed in the class of those members which were continued along the whole length or width of the building. If we are to consider it as painted with the egg ornament, we must, as a necessary consequence, admit some decoration also for the abacus. The architrave again, presents its own flat uniform mass, but it serves as the supporter of rich gilded votive shields and inscriptions. The string-course over the architrave, which unites it with the frieze, must, in reference to the darker color of the metopes, have also been colored, and decorated with a mæander. The triglyphs, as the principal parts of the entablature, would have been white. The fillets below, as Cockerell at least has given them for the Parthenon, would have a graceful palmette ornament, giving them the appearance of the lower borders, or framework of the triglyphs. The guttæ were perhaps gilt. The small band, or fillet, forming the upper corona or head of each triglyph, had probably a similar palmette ornament; whilst the continuation of this fillet, which came above the metopes, would certainly not be white, but colored, in harmony with the colors of the rest. (Such a coating of color would indeed be absolutely necessary, as the heads of some of the figures in the metopes rise in front of

it, and must therefore have been relieved by a darker ground.) The next course immediately above that just described, out of which the mutules project, would have a reddish color, with a mæander running all the way along under the mutules. The mutules perhaps, according to some descriptions, and to keep them in harmony with the color of the metopes, would be blue, with golden guttæ. The string-course which seems to rest upon the mutules, and which is under the corona, was perhaps quite red, to give the greater relief to the white corona above it; the cornice of this corona being distinguished by a graceful painting of leaves. In the same manner would be treated the mouldings of the pediment, the tympanum of which must be supposed blue, so as to secure an appropriate ground for the statues of the pediment. The string-course, or cymatium, would be white, with a delicate palmette ornament in gold; which would thus form a graceful decoration for the upper border of the whole. The acroteria, and the tiles, both those of the ceilings with stars, and antifixæ, were elegantly painted with colors, amongst which gold also was most prevalent. The walls of the cella, if of marble, we may suppose to be white; the frieze for the sake of the reliefs, when there were any, blue. The capitals of the antæ were painted according to the same principles, the neck probably with a palmette decoration. The shafts of the antæ would hardly have been distinguished by color from the walls, since, as was before observed, they are not to be considered as distinct architectural members. The rest of the mouldings were also painted according to the above principles—a broad fillet with palmettes was usually the decoration of the highest member. The beams of the roof were white, with ovolo mouldings. The ground of the soffits was dark, with glittering stars.

The outer wall of the cella appears to be one of those parts, which may fairly have admitted a complete coating of color; which would have given a more striking relief to the peristyles. But it is still a question whether this effect was produced on the sides of the peripteral temples. It seems, on the contrary, rather more probable, that it was confined to the narrower and principal extremities, in order to make these the most conspicuous; where too the depth of the pronaos and the posticus would of itself give to the background a more important feature. This derives confirmation from an expression of Vitruvius, who speaks of this arrangement of the columns as intended to give an imposing character to the building, by the contrast of the intervals; and he at the same time eulogizes the pseudo-dipteros, first introduced by Hermogenes, where the greater depth of the peristyle, by increasing the shadows, makes the depth of the intervals still more remarkable.

But this increased depth of shade would scarcely have been required, if the effect had already been produced by a dark coating of color.

The interior of the cellæ of the smaller temples probably presented to the eye decorations of various kinds: amongst others, we know that they were frequently adorned with real pictures. The interior of the hypæthral temples resembles generally the arrangement of the exterior; but we must suppose the walls to have had a coating of color, as there can be no doubt that plastic works of art, of various descriptions, were here exhibited: and to heighten their effect, a dark ground would have been highly favorable. We refer to what we have already said, when treating of the temple of Olympia.

In *the Ionic order*, the same law essentially exists, as in the Doric: here also we are to consider as colorless the principal divisions of the architectural structure, that is, the columns, architrave, and cornice; but there is no doubt that the decoration applicable to the different members was, in this order, executed in richer colors, as the more complete effect of the details was also provided for, by the frequent introduction of plastic or carved work. This applies especially to the varied ornaments of the capitals, the flowers on the neck, the ogees, and particularly the eyes of the volutes, where there can be no doubt that gold was introduced, as the most efficient element of color. The frieze, which in these temples is the member the most richly decorated, must consequently have had, in its whole extent, a ground of color, probably blue.

The application of this decorative embellishment of color in architecture, so far as the construction of form in general must be considered as its peculiar and essential character, will naturally have been subject to various modifications; and particularly, where a less valuable material required a coating of stucco, it would of course be made use of in larger masses. But it is remarkable, and should be considered as a most fortunate circumstance, that Attica, where the noblest feeling for form was developed, should have been favored also with the possession of the best materials for building, *i. e.* its own native Pentelic marble. We know also, that this, or some similar valuable material, was used in distant countries for the construction of temples.

But what is of still greater importance for the subject in hand, is the very extensive and varied developement of Greek architecture. In Peloponnesus we have on the one hand the severe Doric style; and on the other the elements of Pelasgic architecture, (we allude to the architectural remains at Mycenæ,) present to us still richer application of color. This

was doubtless still more the case in Sicily; for, as we have already mentioned, the remains existing there prove the extensiveness of this usage in individual cases. On the monuments of Pompeii, the mode and manner of painting there practised exhibit a decided degeneracy of the art, and have as little application to the architecture of Greek temples as the private luxury of the Romans. We may also attribute to the causes above described, the rich style of painting observed on the monuments of Etruria: but even here, we can scarcely draw any conclusion to the system of temples, from architectural decorations painted upon the even surfaces of walls. Should we be inclined to lay any stress upon the blue triglyphs of the tomb at Corneto, these (as well as the Sicilian monuments, if the notices given by Hittorf should prove to be correct) may, as we have already observed, be properly considered as belonging to the same system, as that of which the blue color of the triglyphs mentioned by Vitruvius forms a part, and which is now known under the term POLYCHROMY OF ARCHITECTURE.

The following are the principal Works which treat on this subject:—

Quatremère de Quincy: Le Jupiter Olympien ou l'Art de la Sculpture Antique considéré sous un nouveau point de vue; ouvrage qui comprend un Essai sur le goût de la Sculpture Polychrome, &c. &c., 1 vol. gr. in folio, 31 plates, Paris.

Klenze, Leo von: Versuch einer Weiderherstellung der Toscanischen Tempels. —— Memoirs of the Royal Academy of Sciences of Munich, tome viii. 1821.

Angell: Sculptured Metopes discovered amongst the ruins of the Temple of Selinus in Sicily, folio, London, 1826.

L. Völkel: Ueber den grossen Tempel und die Statue des Jupiter zu Olympia. —— Archäologischer Nachlass herausgegeben von K. O. Müller.

Bröndsted: Voyages et Recherches en Grèce, 2 vol. 4to. Paris, 1830.

Hittorff: "De l'Architecture Polychrôme des Grecs, ou Restitution complète du Temple d'Empédocles, dans l'Acropolis de Selinunte," in the Annali dell' Instituto di Corrispondenza Archeologica, vol. ii. p. 263, &c. —— Zanth Architecture Antique de la Sicile, fol. Paris, 1829. —— Séance publique de la Société libre des Beaux Arts le 25 Decembre 1831, p. 21, &c.

Hirt: Geschichte der Bankunst bei den Griechen und Roemern, 3 vol. 4to. 1821—7, Berlin. —— Geschichte der bildenden Künste bei den Alten, 8vo. 1833, Berlin.

Von Quast: Nachrichten aus Griechenland, nach mündlichen Nachrichten des Herrn Schaubert, Architekten der K. Griechischen Regierung zuzamengestellt v. F. v. Quast—in Museum—Blätter für bildende Kunst, 1833. —— Mittheilungen über alt und neu Athen, Berlin, 1834.

Duc de Luynes et *F. J. Depacq*, Architecte: Metaponte, fol. Paris, 1834.

Annali dell' Instituto di Corrispondenza Archeologica, Roma, 6 vol. 8vo. 1829, 1834.

Duc di Serra di falco: Antichità della Sicilia esposte ed illustrate, 2 vol. fol. Palermo, 1334.

Semper: Bemerkungen über die vielfärbige Architectur und Sculptur bei den Alten, Altona, 1834. —— Vorläufige Bemerkungen über bemalte Architektur und Plastik.

Blouet: Expedition Scientifique de Morée, fol. Paris, 1834-5.

Raoul Rochette: De la Peinture sur mur chéz les Anciens; Journal des Savans; Dans les cahiers des mois de Juin, Juillet, Août, 1833. —— Peintures Antiques inédites, précédées de Recherches sur l'emploi de la peinture dans la décoration des Edifices sacrés et publics, chez les Grecs, et chèz les Romains, 4to. Paris, 1836. This volume has just been published as a supplement to the *Monumens inedits* of this author.

Letronne: Lettres d'un Antiquaire à un Artiste sur l'emploi de la peinture historique murale dans la decoration des Temples et des autres edifices publics ou particuliers chez les Grecs et les Romains, 8vo. Paris, 1836.

Dr. Kugler: Ueber die Polychromie der Griechischen Architektur und Sculptur, und ihre Grenzen, 4to. 1 pl. Berlin, 1835.

Account of the Ruins of the City of Anni, in Armenia, extracted from the Journal of W. J. HAMILTON, Esq.

Communicated by W. R. HAMILTON, Esq.

WE left Cars on the 13th of June, 1836, and on the following day, about six A. M. we came in sight of the ruins of Anni, and although still distant, we perceived enough to assure us that our expectations would not be disappointed. Near the ruins is a modern village, built in a rocky chasm, on the sides of which are many caves, which appear to have served as tombs to the ancient inhabitants * of Anni.

The ruins are situated about a mile to the south of the present village,

* A few remarks respecting its ancient history, may perhaps be interesting, although little certain is known respecting it. Anni, which is a few miles N. E. of Cars, on the frontiers of Armenia and Georgia, was the capital of the Paksadian branch of the Armenian kings, a family which, at the destruction of Jerusalem, removed into Armenia.

A. D. 637. The Arabian Caliphs having conquered Persia, first invaded Armenia, then under the dominion of the Byzantine Emperors.

A. D. 885. The Paksadian family having been highly distinguished by the Mahommedan Governor of Armenia, was presented with a tributary crown by the Caliph of Bagdad.

A. D. 961. A branch of the Paksadian Kings established the kingdom of Cars.

During all this time, the influence of the Arabian monarchs sensibly diminished, and at length the Turkish hordes bursting forth from Central Asia, invaded Armenia, ravaging and devastating the country.

A. D. 1046. The family of the king of Anni, who had bequeathed his capital and kingdom to the Greek Emperor, on condition of being defended during life from foreign invasion, was transferred from the throne of Armenia, where they were called (Schahanschah) King of kings, to the proprietorship of a few towns in Cappadocia. After this the Seljukians were more successful.

A. D. 1049. The Tartar tribes sacked Ardzen, a city near the modern Erzeroum, levelling its eight hundred churches to the ground.

A. D. 1063. Toghrul their leader died. He was immediately succeeded by Alp Arslan, who took and pillaged Anni, the capital of the Paksadian Kings, with dreadful slaughter. He subsequently gave Anni to a family of Curds, but after an obstinate struggle they were dispossessed by the Kings of Georgia.

Further details respecting this interesting town might probably be obtained by referring to Cham Chean's History of Armenia, and which would also elucidate many interesting points respecting its ruins. See also Smith and Dwight's Researches in Armenia.

and about twenty-four miles nearly due east from Cars, on the banks of the Arpachai, or northern branch of the Araxes, consequently at the very limit of the Turkish territory. The town is built in a triangular form, on a kind of rocky peninsula. On the east it is defended by steep cliffs, at the bottom of which flows the Araxes in a deep and winding gorge, and on the west by a deep dry ravine of considerable breadth, on the steep sides of which are excavated thousands of tombs and caverns. These two valleys meet at the apex of the triangle towards the south, whilst towards the north, which forms the broad base of the triangle, and where the town joins on to the general flat table land of the country, it is protected by strong massive walls, in many parts double, and defended by numerous round towers. Outside these walls are two small chapels with Armenian inscriptions, in ruins, and in the same style as the buildings within the town. The walls of the town are in some places of great height, from forty to fifty feet, and are well and beautifully constructed. The outer casing consists of large square blocks of stone closely fitted together; the stone is yellow from the immediate neighbourhood. A striking effect is produced by occasionally introducing alternate courses of a black stone, as well as by crosses and other ornaments in black stone, which are sometimes worked into the wall.

We observed two gateways in this wall leading into the town. The most western one, which is flanked by towers of great height, is so blocked up with fallen fragments, that it is impossible to enter by it. We entered the town by the easternmost gate. It is, however, but little removed from the centre of the line. The wall is here double, and the gateways through them are not upon the same axis. The inner gate, as in the old fortifications of Trebizond and Erzeroum, is considerably to the left of the outer one, the road leading for a short distance between the two walls. On the inner wall, opposite to the entrance in the outer one, are some Armenian inscriptions, and a lion rudely carved upon the wall. The inner gateway is flanked by round towers. At the base of the left hand tower are three niches, close to the gateway; each is filled up with a large stone, on which is carved a Latin cross, surrounded by a twisted kind of arabesque also carved upon the stone. On entering the gateway, we had a full view of this interesting town, with the walls stretching away from us on each side. The ruins, although not so numerous as I had expected, are nevertheless striking and peculiar. The ruins of a Christian town, almost in the state in which they were left when destroyed, eight hundred years ago, cannot fail to be interesting, and when constructed in a style almost peculiar to

the place, and unknown to modern Europe, the traveller who has at length reached this distant and almost mysterious city, cannot but gaze upon them with interest and pleasure.

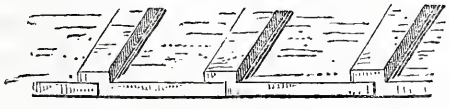
The whole town is covered with the fallen ruins of small buildings and private dwellings, whilst about twenty larger edifices can be distinctly recognized. They are almost all churches and chapels, besides two beautiful octagon minarets, to one of which the mosque is still attached, and the remains of two large buildings, probably palaces.

The principal object, which strikes the visitor on entering the town, is the large Christian church, bearing nearly south from the gateway. It is built in the form of a Latin cross, and is in good preservation. The roof, which is pointed, is formed of large flat stones, supported on arches, and is perfect, except the cupola over the centre. The principal entrance is at the west end. On each side of the doorway are numerous inscriptions in Armenian characters, which would no doubt throw light on the history of the place; indeed, there is hardly a building in Anni which is not covered with Armenian inscriptions. The interior of the church consists of one principal and two side aisles. Its interior length, from the extremity of the semicircular bema, or altar, to the entrance, is 107 feet, its width 66 feet. The style I conceive to be early Saracenic, with perhaps some mixture of Byzantine, and before the introduction of the pointed arch. The round arches are raised upon lofty pilasters, which give them a very different character from the round Saxon arch. This style prevails almost universally in Anni; but in many buildings a greater variety of ornament and sculpture may be seen, gradually approaching the rich Arabic or Moorish style, from which the rich Gothic of the middle ages was more immediately derived. On each side of the bema, in which are twelve arches, is a small dark apartment, and a narrow winding staircase leads to ten more above them. When we were there, this church was full of cattle, reposing during the heat of the day. A short way from the church to the west, is a lofty octagon minaret, with a long inscription in Arabic characters, and one hundred yards more to the south, the remains of a very beautiful mosque, also with its minaret. This mosque is built on the very edge of the precipice, overhanging the Arpachai. It is clearly old Saracenic, the roof being supported by low columns with large sloping capitals, and round arches. In the corners between each two arches, placed at right angles to each other, are various ornaments, in some of which may be traced a great resemblance to those introduced in florid Gothic buildings. The mosque itself is nearly square, one corner only being taken off to sup-

port the minaret. On the outside are inscriptions both in Arabic and Armenian. At the south end of the town, nearly at the apex of the triangle, is an elevated rocky hill, which in a Greek town would have undoubtedly formed the Acropolis. Here however the only buildings, besides the remains of small fallen private walls, are three or four chapels, situated on the summit and on the sides of the hill; and nothing remains to denote that it was ever fortified. On the S. E. side of the hill is also another chapel, in good and rich style; the dome in the centre is perfect, and the roof outside instead of being circular is conical; the same form exists in the other buildings, where the roof remains, and I have no doubt such was the outside form of the cupola of the large church. A slight wall runs round the hill some way below the summit and along the edge of the precipice, probably intended only to mark the limits of the town, as the nature of the ground renders any other defence unnecessary.

Between this hill, which I must call the Acropolis, and the large church, are the remains of another church, completely levelled to the ground. Amongst the ruins are many fragments of fine architecture. From the appearance of the fallen ruins, which are quite different from all the others, less broken, and less covered with soil and rubbish, it would seem to have been thrown down but lately.

Returning northwards from the Acropolis along the western side of the town, are several other buildings striking from their rich style, and deserving the attention of one more versed in architecture than myself. The first is a round, or rather octagon, chapel, about 30 ft. in diameter inside, with seven circular niches and a dome. The entrance occupies the eighth side. Above the cornice, and before the dome and wings, are fourteen small round arched, narrow windows. The niches, I should observe, are more than a semicircle, thus giving the interior a very peculiar appearance. Within the architecture is extremely plain, but on the outside highly decorative. Rich ornamental flutings and fretwork, and deeply carved twisted mouldings run round the windows, and under the cornices. The alternate windows and sides are made to correspond. The roof is conical, and like all the other buildings here, formed of large flat stones, their edges lapping over each other on one side, thus:—



Another interesting building, the remains of a very richly ornamented church, is to the N. E. of the last. Attached to it is a chapel, with a very

beautiful roof. It is arched, but divided into several compartments, each compartment being filled with mosaics of a different pattern, formed of the various colored stones of the neighbourhood. The walls are in parts beautifully carved and sculptured in arabesque patterns. The Latin cross is frequently introduced. The roof is supported by diagonal round arches, the intersection of which produces four Gothic or pointed arches. Very probably the origin of the rich Saracenic and Gothic styles, might here be completely traced, by studying the ornaments of the capitals of the low round columns, and those of the corners between the arches. A regular gradation may be observed from the most perfect simplicity, passing through every stage, to that of almost florid Gothic richness.

Between these buildings and the walls are several others of the same character, which it is unnecessary to describe more particularly.

Near the west end of the walls, a little inside the town, are the remains of a large, extensive building, situated on the edge of the ravine. It has consisted of several stories, and many apartments still remain. The gateway is in handsome Saracenic style, the arch of a large window over the gateway is an ogive arch, and the wall is ornamented with rich mosaic work. It appears to have been the palace, either of the Kings of Anni, or of the Saracenic Governors. The masonry is very perfect, the blocks of stone being fitted with great precision; indeed this is the case with all the buildings that are standing, which are all cased with large square blocks, the edges of which, as well as the angles of the wall, appear as perfect as when first built.

I have already alluded to the many caverns cut in the face of the rocks, in the deep ravines round the town; many of them are sculptured inside, either with architectural designs, or rude ill finished figures. In a large one which I entered, near the palace, the sides are carved and cut to represent columns, capitals, and cornices; and the roof is made to represent arches, thrown across from the columns on each side.

Below the church are the remains of a high narrow bridge across the Araxes, which led into what is now the Russian territory, it is however much destroyed, the buttresses on each side alone remaining.

Such is the present state of this very interesting town, of which Sir R. K. Porter has, in his Travels, given a beautiful description, but without entering sufficiently into the details of the disposition and character of the remarkable architecture, which it presents.*

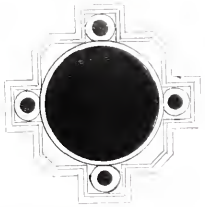
* See also "Ayesha, or the Maid of Cars," by James Morier, Esq. 1834.

CRYPT IN YORK MINSTER.

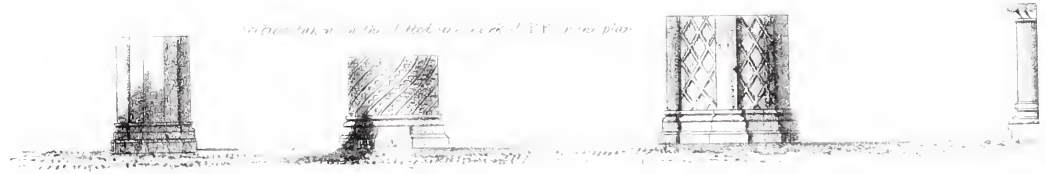
Measured & drawn by P F Robinson, Vice Presid.t

Plate I.

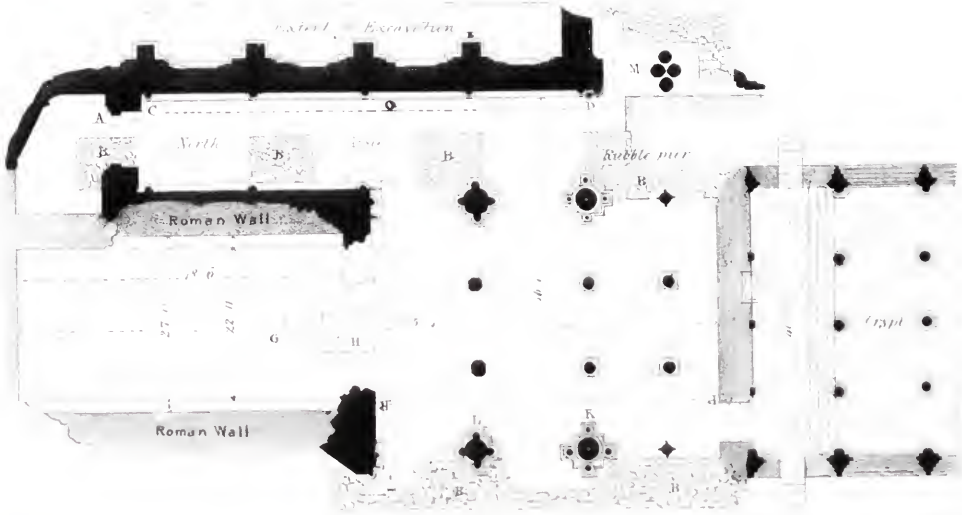
Section taken on the dotted line marked O I on the plan



Plan of Shaft marked K



Plan of Shaft marked L



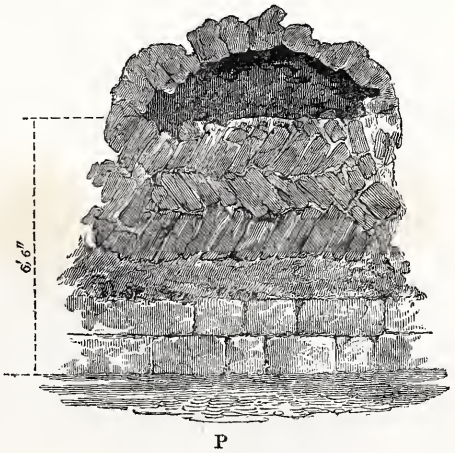
On the newly discovered Crypt at York Minster,

By P. F. ROBINSON, Vice President.

Read at the Ordinary Meeting held Monday, 6th July, 1835.

My professional engagements at York having afforded me leisure to examine the discoveries at the Minster, in consequence of the excavations made in the Choir during the progress of the late repairs, I felt that a correct plan of the recently discovered Crypt, *made from actual measurement*, might prove acceptable to the Architectural Antiquary, and having with great care and attention succeeded in obtaining such a plan, I herewith submit it for the consideration of the Institute of British Architects, accompanied by details which will be explained by the annexed plates 1 and 2. As the Crypt in question is undoubtedly the work of Archbishop Roger, who rebuilt the choir with its vaults in 1171, it is interesting as an example of very early architecture, and the Cathedral may now be considered as affording a history of the art (the organ screen having been most fortunately preserved) from that period, up to the time of the Reformation. Few buildings indeed will afford to the student more exquisite details, or more imposing effects.

The plan No. 1 will explain the form of the newly discovered Crypt. It measures 105 feet 4 inches in length by 56 feet in breadth, and extends from the Crypt, formerly supposed to be the only one, to the base of the great central tower or transept. That part marked black will explain the form of the tooled masonry, the remainder is rough common walling, or rubble. The lighter tint indicates the extent of walling erected in the Roman manner, of which the following wood cut affords a specimen.



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The walls of this Crypt are entirely independent of the superstructure, nor are they parallel with the work above, and it appears, upon carefully examining the plan, and the form of the remaining masonry, that the width was originally 72 feet 6 inches, whereas the Choir erected by Archbishop Thoresby in 1361 measures (including the side aisles) 100 feet. It is evident that a side aisle corresponding with that forming the northern boundary, must have existed, as the small cylinder marked I on the plan, will sufficiently indicate. At the western extremity of the north aisle, a doorway of very elegant and curious workmanship was discovered, and as this doorway afforded access to some work extending still more to the westward, it is to be lamented that the excavations were not continued, the very small portion contiguous to this door having exposed some tooled masonry forming an angle, for which it is difficult to account. The continuation of this wall is enriched with cylinders. The plan and details, shewing one jaumb of the door, are explained by plate 2, which will in some degree exhibit the beauty and elegance of the workmanship. The outer surface of the north aisle is decorated by buttresses, having recesses between them, enriched by cylinders, a very small portion of which now remain above the bases, (see the plate No. 2.)

The rubble piers marked B on the plan, support the great shafts of the Choir, and they are not parallel, as I have observed, with the walls above. Numerous relics of an earlier structure are worked up in these piers, such as bases and capitals of cylinders, with fragments of zig zag ornament. The inverted capital acting as a base to one of the columns in the adjoining Crypt, is no doubt a portion of the same edifice.

Edwin the Saxon King was baptized by Paulinus the Bishop, April 12, anno 627, in a little oratory of wood. Edwin began to build a magnificent fabric of stone. "In quo postmodum loco per quadrum ædificata basilica, doctori suo Paulino sedem apiscopatris dedit," (Bede.) Oswald succeeded Edwin about 632, but died after the building was demolished.

Bede tells us this temple of stone was a square building. "Templum per quadrum ædificata."

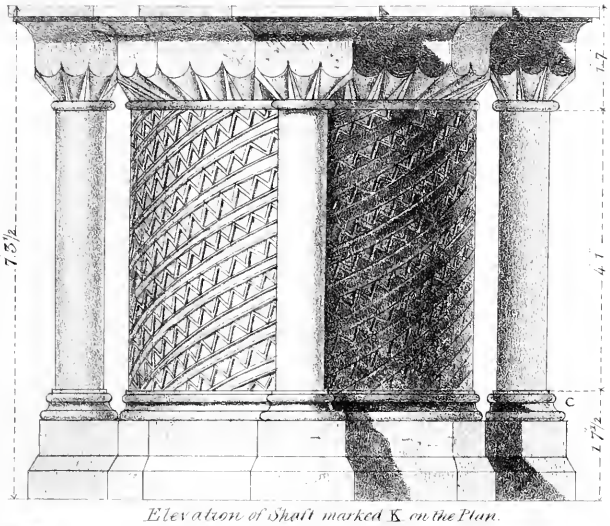
Wilfred repaired the building 669, and it lasted four hundred years. It was burnt down 1069. Thomas rebuilt it anno 1070. It was again burnt down 1137, after which Roger rebuilt the choir, *with its vaults*, in 1171.

That part of the plan enclosed by walls, erected in the Roman manner, measures 48 feet 6 inches by 22 feet 11 inches, increasing at the height of 20 inches above the ground to 27 feet in width. These walls are on an average 6 feet 6 inches in height, and they form the outline of some very

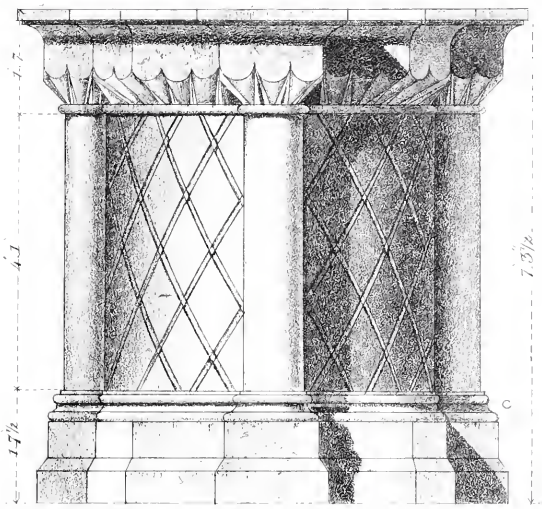
CRYPT IN YORK MINSTER.

Measured & drawn by P F Robinson Vice Presid.t

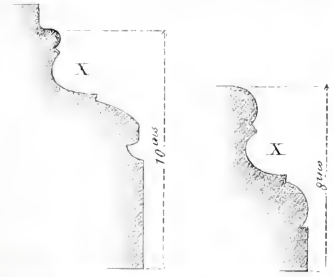
Plate 2.

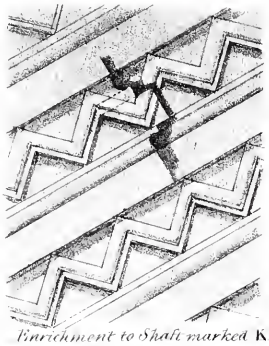


Elevation of Shaft marked K on the Plan.

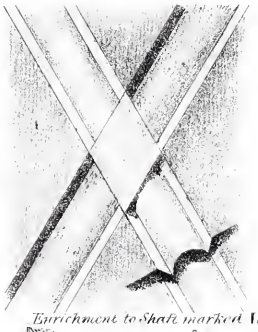


Elevation of Shaft marked L on the plan

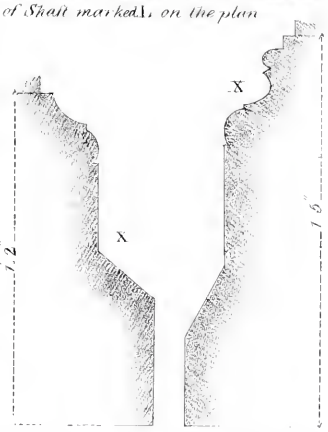


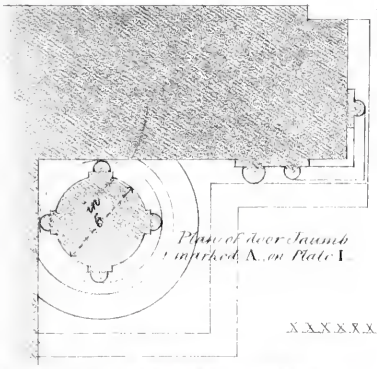


Enrichment to Shaft marked K

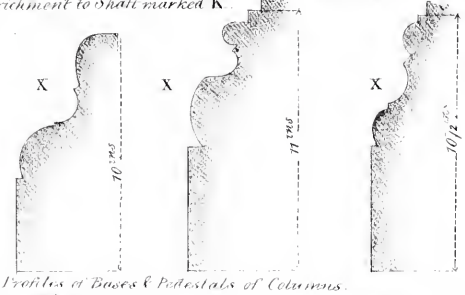


Enrichment to Shaft marked L.

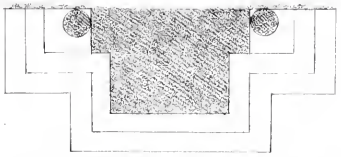




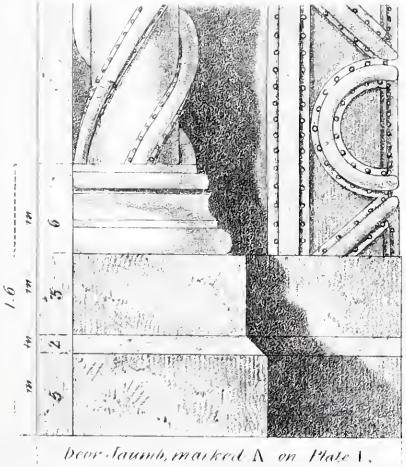
Plan of door Jaumb marked A. on Plate I.



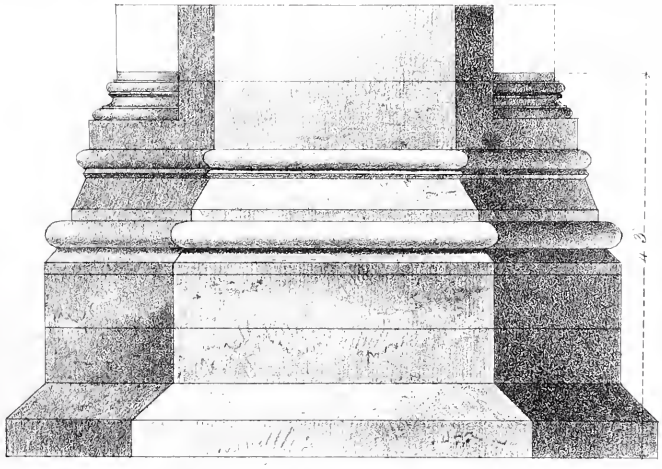
XXXXXXXX Profiles of Bases & Pedestals of Columns.



Plan of Buttress marked E. on Plate I.



Door Jaumb, marked A on Plate I.



Elevation of the Buttress marked E. on Plate I.

to C Brighe Esq.r to the King

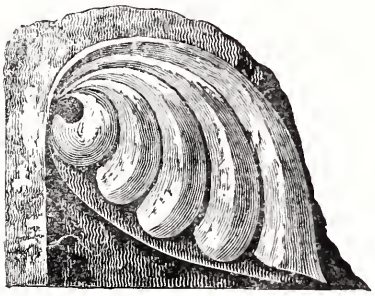
early structure, the shape indicating very much the cell of a Roman temple. The floor of this cell (if I may so distinguish it) is about 1 foot above that of the Crypt, and in the centre, two rude masses of rubble walling, marked G and H on the plan, have something the appearance of an altar, particularly that marked G.

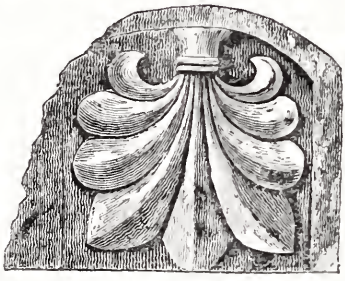
But the most interesting features to the architectural antiquary, are the form of the large shafts, explained by plate 2, enriched with attached cylinders, and with cylinders detached from the central column or shaft, affording the earliest example, perhaps, in this country, of a similar mode of enrichment. In the Crypt to the Trinity Chapel in Canterbury Cathedral, erected at the same period, the shafts are quite plain, as indeed are those in the larger Crypt adjoining, and the same may be said of numerous contemporary buildings. In St. Sepulchre's Church at Cambridge, considered by Mr. Essex* to have been erected in the reign of Henry I., the shafts are plain, as are those in St. Sepulchre's Church, Northampton. The same is to be observed of the Baptistery at Pisa, built by Dioti Salvi in 1152; and the following buildings exhibit examples of the same character: the Crypt in the Abbaye aux Dames at Caen, the Crypt to the Cathedral of Bayeux, Malmesbury Abbey Church, St. Peter's Church Northampton, Kirkstall Abbey, and many others. The four columns at the junction of the eastern transept, with the Choir in Canterbury Cathedral, afford an early example of detached clustered columns.

Upon carefully examining the plan, it will appear that the two Crypts never were united, as the columns or shafts are not in line, nor indeed are they planned in any way to range or correspond. It may be presumed therefore that they were not erected at the same time. On the northern side of the newly discovered Crypt, some appearance of a Cloister may be discerned, indicated by the aperture marked M on the plan, and by the clustre of cylinders, which it is interesting to observe are independent of each other. Should it be supposed that this marks a transept or cross aisle, then some work extending further eastward must have existed. Indeed it appears by the abrupt termination of the groined ceiling, that the Crypt nearest the altar originally did extend farther eastward. Upon the whole, the recent discovery must prove interesting to the Architectural Antiquary, and will probably open a field for much conjecture.

* Archæologia, vol. vi. p. 173.

The two sections (plate 1) will shew the various heights of the masonry, as it now appears, and the plate 2 the curious profiles of the moulded bases, the enrichments on the angles of which are represented in these wood cuts.





LITERATURE, &c.

On the Benefits resulting to the Manufactures of a Country, from a well directed cultivation of Architecture, and of the Art of Ornamental Design,

By J. B. PAPWORTH, Vice President.

Read at the Ordinary Meeting held Monday the 27th of July, 1836.

The very extensive knowledge necessary to be acquired by long and difficult research and careful study, before an Architect can be prepared to fulfil the duties imposed on him by liberal patronage and employment,—is a fact better known to him, who has had the vast labour to contend with, than to any other;—and every Architect who loves his art, and has a just sense of the deep necessity of possessing its qualifications, must regret that this country has not, until lately, possessed an association of its members willing to make smooth the rugged path of the youthful aspirant, and to assist his objects by all the means in their power, as well as to create a communion of information among its elder branches. And it must be understood, that the oldest in this art, if really zealous as an Architect, however he may be distinguished by patronage, or by the honourable opinion which is bestowed on him by his brothers in the profession, is still a student, and continues to be so to the last moment that his physical powers enable him to contend with its duties.

The benefits, which have accrued to every country by the advancement of its polite arts, are so perfectly and so generally confessed, that words would be vainly expended by an endeavour to prove them: and perhaps it would be equally unnecessary to shew that any particular art had more or less claim than another, in a general point of view, to be regarded as the medium of great benefit to a country.

But Architecture embraces so much variety in the art of design, inclusive of Sculpture, besides much of the sister art of Painting, all which have reference to ornamental manufactures, that *its* advancement demands a paramount regard and cultivation. It is to *Architecture* that the manufactures look for their *best* assistance, and in those countries, in which it has received the most encouragement, they have acquired an acknowledged superiority for purity in taste. To an Institute like the present, this country

will look forward, to receive from it all the benefits that study, intellect, and industry can bestow; and it has already experienced some fostering assistance, which, when its objects are better known, will doubtless pour in upon it in a just proportion to its merits.

The reputation of our manufactures, as relates to the art of design, is necessarily in no great esteem with foreigners, nor indeed with ourselves, because its artists have not received payment, nor honors, much beyond those bestowed on common workmen. These have probably been withheld by the manufacturer, because he is not secure of reaping that benefit which ought to accrue to him for an adequate outlay: for the protecting laws, which are necessary to give him fair rights in such property, are at present quite inadequate to ensure to his only use that, which he has bought and which may speedily be pirated from him. Artists themselves suffer greatly by this deficiency, but there is reason to believe that the legislature will very soon afford the means of ample protection.

Then, and not until then, whatever may be the desire of the artist or the manufacturer, works designed on *pure* and *classic* principles, or those, which have prototypes in the *best Grecian, Roman, or Italian works*, will go forth to the public; these are so amenable to accurate criticism, that none but first-rate artists can design or execute them with success. This talent requires great study and a thorough acquaintance with the best works in art; but whenever that time arrives, and it is much to be desired, the whole style now so much adopted, the style in which show and specious flicker, the "quips and cranks and wanton wiles" of the times of Louis XIV. and XV. are substituted, will give way to the graces of truth and beauty, as they have been handed down to us in the works of the great and classic masters.

But it is not a matter of surprise that the bad style has so prevailed, and for so long a continuance, when it is a well known fact, that the least capable workmen, of whom there are many, succeed better in the design and execution of this grotesque manner than the highly educated and tasteful artist, of whom there are very few.

It is a part of the duty of an Architectural Institute to reclaim all this; it will be a work of labour, but it is important to the reputation of the arts and to the best interests of the architectural, as well as the manufacturing, art of the country. In viewing the progress of architecture from very early times, it is evident that with the improvement of the human mind its works participated, and became a matter of just emulation between countries, and a medium for conveying the evidences and workings of intellect to future times.

Perceiving the estimation in which were held the vast edifices of Egypt, which so amaze us at this day by exhibiting the command of physical means in their erection, the Greeks, unable to vie with them in such mountainous structures, fortunately for art, resolved to employ a superior substitute, and by every means identify the operation of profound study, united with cultivated intellect, in every work, *however minute*, which came under their direction, and this is our duty also.

In the best works of the Grecian architects, we know by a careful study of them, that every part was the result of reflection, and that many things which would seem to be right according to mathematical precision, are discarded for that which is right in true art, but which would otherwise fail to produce those excellencies.

The Romans, inspired by the fame obtained by the architecture of Egypt and Greece, established their own style, which the Italians have so elegantly made subservient to domestic architecture.

Other countries, adopting or substituting portions of early art upon their own styles, always identifying mind with the material, have produced a variety perfectly distinguishable from each other, probably caused by local circumstances, which made another manner unsuitable to their means. All however labored to make the combination of great value, by the testimonies of genius which they produced, abounding with the feeling so well expressed by Sir William Chambers,—"It is not to be imagined, that building, merely considered as heaping stone upon stone, can be of great consequence, or reflect honour either on nations or individuals: materials in architecture are like words in phraseology, having separately but little power, and they may be so arranged as to excite ridicule, disgust, or even actuate the mind with unbounded sway. An able writer can move even in rustic language, and the masterly dispositions of a skilful artist will dignify the meanest materials, while the weak efforts of the ignorant, render the most costly enrichments despicable."

That, which is usually understood by the public to be the art of Architecture, is of too abstracted a nature to correspond with its just application. Architecture embraces the whole art of design, in all the means which its study can supply, in composition, proportion, ornaments of every kind, light, shade and color. He therefore, who delegates his power over any of these in the building which he erects, as considering them inferior in his art, is not fully embued with the true spirit, or otherwise does not find a remuneration adequate to his exertions. When the patronage of a country does not supply this, it is deficient in being a fostering patronage.

This paper will be properly concluded by another observation of Sir W. Chambers, as from his sound and judicious mind these sentiments may receive trustworthy confirmation,—"The progress of other arts depends on that of architecture,—when that is encouraged, painting, sculpture, and all the inferior branches of decorative workmanship must flourish of course, and these have an influence on manufactures, even to the minutest mechanical productions; for design is of universal benefit, and stamps additional value on the most trifling performances, the importance of which to a commercial people is obvious,—it requires no illustration."

Gentlemen Associates, permit me to recommend to you the study of the art of design in every matter that is legitimate to your profession, and I know of no Architectural feature which is not intimately connected with it. It will produce to you ready facilities applicable to your pursuits, be a continual source of amusement and delight, in addition to which you will be possessed of an invaluable means of benefiting your country.

Some Particulars relating to Manuscripts of Vitruvius preserved in various European Libraries,

Communicated by THOS. L. DONALDSON, Honorary Secretary, Corresponding Member of the Institute of France.

Vitruvius is the only ancient writer, treating specifically on Architecture, whose work has been preserved entire to the present period. The value, in which he has been held by the moderns, has been as various as extraordinary. Upon the revival of ancient literature in Italy, the treatise of our author was in high estimation, merely as a work of the ancients. It was natural, at a time when the literature of the country was in its infancy, to look up to the productions of the Greeks and Romans as models of perfection, having been produced in times when the human mind was more highly cultivated and refined, and endowed with the best fruits of a finished education. But there was another cause which gave him value, and this arose from the revival of ancient art also, which began to supersede the Gothic, Byzantine, Lombard, Tedesco, or whatever other style of Architecture it may be called, which was then prevalent in Italy, and from the disorganized mass of Roman antiquities not having been then adequately studied, and consequently being very imperfectly understood. The various combinations, which directed the conceptions of ancient genius, had therefore not been discovered. When, however, a reference to Vitruvius brought to light the three divisions or species of columns, and all that order and method of arrangement which he describes, he became of course the text book of Architects and writers upon Architecture, and his dictum was held in absolute respect.

This reverence was, in subsequent times, rather perhaps the result of a blind respect for established opinion, than the fruit of a minute investigation of the author himself; until at length a revulsion in the opinion of some arose, and of late it has been the fashion as much to depreciate his merits, as it was formerly the practice to exalt them. This has been as unwise as it is unjust; for although Vitruvius can by no means be considered as an author devoid of defects, yet it cannot be denied that he contains informa-

tion connected with our art, which exists not in other sources. Alberti, whose eminence as an Architect it would be vain to attempt to depreciate, has made his work, *De re ædificatoriâ*, but an amplification of that of the Roman, borrowing, as has been well shewn by Stratico, whole paragraphs from an author, which he has but enlarged. Pliny quotes him almost word for word, and it would be useless to attempt to cite the numerous references among moderns, which are made to the books of Vitruvius.

Much of the misconception, and many of the errors attributed to Vitruvius, may be referred to the numerous corruptions, which have been introduced into the original text of our author. The *editio princeps* is a faithful transcript of some codex; but Jocundus, the second editor of the text, thought to clear up the obscurities, which prevailed at that period in regard to some parts, and very unceremoniously, without reference to other MSS., introduced or altered words and sentences, without indicating to his reader what was the original reading of the codices, what the interpolations which he had so daringly allowed himself to make. Unfortunately, from the scarceness of the *editio princeps*, which was soon exhausted, or from the great reliance placed in the learning of Jocundus, his edition has formed the groundwork of every succeeding edition and translation until the present century. Gottlob Schneider published at Leipsig in 1807, the first volume of his work on Vitruvius, founded upon a collection of various manuscripts, which will be noticed. This is now completed, and is enriched with various readings, emendations and notes of the most learned and valuable description. Simon Stratico has since published at Udina another similar work in 1825, in quarto, containing also the exercitations and disquisitions of various writers on our author. This is also a valuable work of reference for the architectural classic.

It is to be hoped that some one of the well qualified of our architects of the present day, and there are more than one well qualified for the object, would rescue this country from the reproach of being indifferent to the absence of a correct English edition of the Latin text. Our manuscripts are numerous and of the best description, and with the view of pointing out the sources open to enquirers in such a field, the following particulars are given of several of the *Codices Vitruviani* preserved in public libraries of Europe. It is not attempted to give a critical disquisition upon each manuscript, but merely to offer a few general particulars, which may enable the reader acquainted with MSS. to judge of their relative value. These notices are in some instances more minute than in others, for I have in regard to some only been able to ascertain that they exist in certain libraries. Perhaps

some of the correspondents and members of the Institute may have the opportunity of making more exact enquiries, so that we may be able hereafter to add to the present brief notice, information of a more accurate and valuable description.

MSS. OF VITRUVIUS IN ENGLAND.

BRITISH MUSEUM, LONDON.

Harleian MS. No. 2767, indorsed SEC. IX. This codex is entitled to be regarded as the most valuable of those in the British Museum, not only on account of its reputed age, but for the correctness of its text, and the absence of all omissions. It is the only subject of a small folio volume, and is written on vellum, in single columns on each page, and in fine bold characters. The headings of the books, and original divisions of the chapters, are in letters of a brilliant red color, as fresh as when first put on, except on the first page, which is soiled from use. The heading of the second chapter has the following interpolation of the transcriber, "Liber primus explicit Dō gratias amen. Incipit liber secundus." The last book concludes in a similar manner. There are frequent capital letters in black ink, as though indicating the commencement of paragraphs, but in many instances obviously erroneous. I have not discovered a single omission. The abbreviations are very rare, and a peculiarity is observable in the small *s*, which is generally given as the *r*, except in the beginning of words, or where it is double, when it is written f and ff. *Et* is written in the middle of words, as "*&*," thus in *symm&riae.*

Harleian MS. No. 2508. According to the indorsement this is a manuscript of the xvth century, and is one of many subjects, military, religious, literary and scientific, that make up the folio volume, and all which seem to have been transcribed by the same hand, I should think at Florence. The text is written in single columns to each page, and on paper; the words are very much and very frequently abbreviated. There is a very complete index at the head of the work of our author, dividing the books into chapters; and the capital letter of each book is a large one written in red color. The first letter of each of the chapters is also larger than the rest. Various passages are left out, and in effect the departures from palpable propriety are so great in many instances, as to render its variations from other manuscripts of little value.

Harleian MS. No. 2760, indorsed sec. xiv. The only subject in a quarto volume; and is written on vellum in single columns with a remarkably neat character, the ink in parts however being much faded or rubbed. The capital letters at the head of each chapter are illuminated. This codex is full of abbreviations, the sure sign of a late period, and several serious omissions occur, the eye of the transcriber having been deceived by the near repetition of the same word.

Harleian MS. No. 3859, without indorsement. The ten books of Vitruvius form one of several subjects in the same quarto volume, and are written on vellum in single columns. The headings and first letter to each of the books, as well as the first letters of certain divisions in the first book, are painted a flat tint in red or green, or both. The abbreviations are much more frequent than in No. 2767: the same sort of character is employed as in that Codex, but smaller. In the paragraph almost immediately succeeding the description of the diminution of the openings of Doors, which properly runs thus: "Supercilii crassitudo *quanta antepagmentorum in summa parte erit crassitudo,*" the words in italics are omitted, the copyist having been deceived by the quick repetition of the word *crassitudo*. The compiler of the Harleian Catalogue remarks upon this Codex, "*exemplar admirabile, et quantivis, ut videtur, pretii.*"

Harleian MS. No. 4870. The indorsement attributes this manuscript, which is of the quarto size, to the xvth century. The text is written on paper in double columns to each page, with much less care than the Codex at the head of our list. It appears never to have been completed, as the capital letters, intended to be put at the heads of the books, are omitted altogether, and the other principal letters at the beginnings of chapters are inserted in a careless manner, apparently by a subsequent hand; and the red ink in which they were written is become quite pale. Various errors of gender and termination are frequent, evidently the fault of the transcriber. The abbreviations are few and obvious, and omissions occur of words and sentences in various parts.

Cottonian MS. Cleopatra D. 1. There is no indorsement to this volume, which is in large quarto, but judging by Caisley's κριτήρια it appears most probable, that this Codex may be considered as belonging to the period prior to the xiith century. The text of Vitruvius forms one of several

subjects that compose the volume, and is written on vellum in single columns on each page: the characters are clear and distinct, the *i* has no hair stroke over it; but few abbreviations occur, and they obvious. The headings to the books are in red, which, from being originally composed of a greasy substance, has spread and disfigured the parts near: the capital letters are frequent, and are touched with red ink on the orginal black letter, to render them more conspicuous. The same omissions already remarked in the Harleian MS. No. 3859 occur from the quick repetition of the same words.

It may be presumed that this Codex is the one mentioned by Schneider, vol. I. pp. XXXI-II. as having been examined by Isaac Vossius, whose critical notes founded upon this MS. are made use of by Bondam in his Variæ Lectiones, edited Zutphaniæ 1759.

New Series, No. 122. A small folio volume, written on 145 leaves of vellum, supposed to be of the xvth century. This volume forms part of the Arundel collection, which was in the possession of the Royal Society, and by that body transferred to the British Museum in 1831. From a memorandum on the first sheet, it appears to have been purchased at Siena on the 14th June 1614. The first page has an illuminated margin round three of its sides, and the first C, as also the heading letters of each book, is also richly illuminated with gold and colors: the first letters of some of the chapters are a plain blue letter, but occur very seldom. It is written in a single column on each page, with a fine round character, with very few contractions; the diphthongs *ae oe* are invariably written with a single *e*, and the *i* has neither hair stroke nor dot over it. It is mentioned in Evelyn's Diary, 1678, August 29, as *a noble MS. of Vitruvius*, and is the one enumerated in James' Catalogue, the number in the Arundel Catalogue being 122 Plut. This Codex is most incorrectly bound up, many sheets being misplaced.

MSS. OF VITRUVIUS AT OXFORD.

F

Bodleian Library, MARKED AUCTAR 5. 7. This is the only one which appears to be preserved in this library, although James in his Catalogue of the MSS. of England and Ireland enumerates two. This Codex was bought in London by the present Librarian, about the year 1820, at the Abbé Celotti's sale: it is in excellent preservation, and although it has no date, appears to have been written in the sixteenth century. It is the sole subject of a quarto volume, written in single columns on each page, on vellum. The

capital letters to the heads of books and other divisions are large, written in blue and red colors, and some illuminated with gold. The *C* of "*Cum divina tua mens,*" at the very commencement is embellished with a colored half figure of a person in a scarlet cloak reading a book. The text appears to have been written by two or more scribes at different periods, the two first books being in a larger character than the eight last: there is usually a hair stroke (′) over the *i*, but frequently no mark at all, and the diphthongs *ae oe* and the letter *e* are all written *e*. The abbreviations are frequent, in fact to almost every word. Many of the numbers, expressed by words in the most ancient copies, are in this codex written with numerals. Omissions occur of words and sentences. The Codex numbered 7541 by James as being in the Bernard collection, the greater part of which is in the Bodleian Library, is now to be found there, but is merely a printed edition of Vitruvius, containing some marginal manuscript notes.

Library of St. John's College, No. 66. This is the one numbered 1926 by James, in his Catalogue of Archbishop Laud's MSS. this collection having been left by that prelate to this college, of which he had been the head. The books of Vitruvius form the sole subject of a folio volume, the text being written on vellum, in single columns to each page. There are very large capital letters in blue and red characters at the heads of the chapters, and embellished with thin blue or red marginal curved lines, a practice most frequent at the period when this Codex was written. The abbreviations are frequent; no diphthongs, nor any strokes, nor dots over the *i*. There are some omissions observable. At the end is this valuable addition, which defines the very day and place of its completion, the 24th December, 1316. **Completus est iste liber p̃die vigiliarum natalis Dmi. anno Dmi. m̊=c̊c̊c=xvi̊. Radulpho de Bourne tunc Abbega August Cant.**

MS. OF VITRUVIUS AT ETON.

The College Library, marked in the Catalogue B. 1. 4. 10. It forms the sole subject of the volume, which is small folio, and is written on vellum in single columns on each page. It is bound, and well preserved, although perforated in some parts by worms, and seems written throughout by the same hand, except some corrections and marginal notes by apparently a different person. These marginal notes merely refer to the subject of the text, or give the Greek characters of Greek words, which in the MS. are

always in the same character as the rest of the text, latinised. The corrections over words, which are not very numerous, seem to be sometimes by the original transcriber, and sometimes by a later hand. The capital letters at the heads of the books are nearly an inch high, and are illuminated with blue and red colors; those at the heads of the sections are not so large, and are colored red. There are hair strokes (') over the *i* instead of the dot (·); the "*et*" in the middle of words is not written "*&*" as in some manuscripts; and the diphthongs *ae* and *oe* are written with a simple "*e*." The abbreviations are frequent but very intelligible.

Immediately after the opening Proem to Augustus there is a table containing the titles of the different sections, written in the same character as the rest of the Codex. They are afterwards repeated in red letters at the head of their proper sections.

On the fly leaf of the manuscript is the following paragraph:

"Vetruvius Nobilis Archytectus exactissimi vir Ingenii. Olim ex bibliotecha clarissimi Mathematici Jacobi Langusci Veneti. Post ejus casum Patavii subastatione multis cum aliis in Nostratium usum deductus est Anno Salvatoris Mcccclliij. Tandem multiplici codicum* usu ex indulctu præbito quod raritas tunc librorum effecerat Veluti transfuga xx ferme annos nobis delituit nescio ne obscurus in ulvâ ut Poeta diceret. Demum hodie Paulus Cornelius Ludovici Filius quum de Arrigis dictitaret id certior factus ex nostratibus hunc fuisse nobilem Archytectum bona meute indutum veteri domino destinandum curavit. Quod bono omine xvi Junii 1493 factum est. Quo die opportune [†] quanti habenda sit deperditorum recuperatio, et quam celebri gaudio exilarandum sit mentibus dominorum! cum redemptio est deperditarum rerum insperato facta his qui jacturam optatissimorum gaudiorum ex usu suavissimorum magni pensandam esse statuerunt juxta illud petrace [Petrarchæ?] nostri. Che piu gloria é nel regno degli ellecti dun Spirito converso, et più si stima che di novanta nove altri perfecti. Id nostri Bernardi Bembi doctoris manus."

For the above particulars, the Institute are indebted to the Reverend G. R. Green, one of the Fellows of Eton College.

VENICE.

The Library of St. Mark possesses four Codices:

First.—A Manuscript, presented by the Cardinal Bessarion to the Re-

* *Amicorum* in the original.

† The words in the space between brackets could not be deciphered, as the MS. is perforated. The last words appear to be "missarum Boloniis. sed"?

public, contains the entire work of Vitruvius, written on vellum, in quarto, and supposed to be of the xvth century. It is described in the printed Catalogue published in 1741, under the No. ccccliii. among the Latin MS. Codices.

The Second.—It is not known how this was procured; it is also written on vellum, and is supposed to be of the xvth century, and is numbered xxiii. in class viii. of the Appendix to the Latin MSS.

The Third is written on paper for the use of Giovanni Poleni in the xviiith century, in quarto, from an ancient manuscript preserved at Cesena, and is entered in the same Appendix, number xc. in class viii.

The Fourth, also on paper, of the xviiith century, in folio, does not contain the entire work of Vitruvius, but only various readings taken from the MS. Codices preserved in the Florentine, Laurentian, Parisian, Vatican, Bolognese, and Leyden Libraries. These are contained in four Codices marked No. xci. xcii. xciii. xciv., class viii.

The Library of St. Mark contains two manuscript copies of the Italian version of this author, by Daniel Barbaro.

The First in the written Appendix of the Italian MS. Codices is numbered xxxvii. class iv., and contains the four first books written by his Amanuensis, with emendations in the hand-writing of Barbaro himself; the form is folio, written on paper, and of the xvith century.

The Second, also on paper, and in folio, of the xvith century, contains the entire version and the Italian commentaries of Barbaro, written by himself, and in the same Appendix of Italian MS. Codices is described under the number clii. of the same class iv.

In the edition of Vitruvius by Simon Stratico, p. 113, mention is made of a MS. in the library of the Signor Girardi Sagredi, Procurator of the Church of St. Mark at Venice, which bears a date of 1404.*

MSS. OF VITRUVIUS AT PARIS.†

Bibliothèque du Roi. No. 7227. A small folio volume, supposed to be of the xith century. There are no colored letters or illuminations. The

* For these particulars I am indebted to Signor Pietro Bettio, the learned Prefect of the Royal Library of St. Mark.

† My friend Mr. F. Stamman, Architect, of Hamburgh, has furnished me with these details, having expressly examined these Codices for me during a short professional visit, which he recently made to Paris.

text is written in a single column on the whole page on vellum. The abbreviations are frequent, but very intelligible: the *ae* and *oe* are written with a single *e*, and *et* in the middle of words with an &. This fine Codex appears to rank with the Harleian MS. No. 2767, already noticed.

No. 7228. This is a small folio volume, written in double columns on each page, with frequent abbreviations. There is a fine illuminated title page, painted with three portraits, which are in the Florentine costume, of the time of Cimabue, like in the old Italian frescoes. The capital letters, and some of the smaller ones on the other pages, are also colored. All these peculiarities are a strong presumption that this Codex is of the xvth century, although it is generally attributed to the xivth.

No. 7382 is thought to be of the xvth century: it is in quarto, written in single columns on each page, on paper, and almost without abbreviations. It formed part of the Mazarine Collection.

There are also two Codices, numbered 6842 and 7229, both containing merely the tract of the anonymous author, extracted from Epaphroditus and Vitruvius.

*MSS. OF VITRUVIUS AT LEYDEN (LUGDUNI BATAVORUM.)

The University Library possesses three Codices, forming part of the Vossian Collection, in which they are numbered 83, 55 and 95: but in the Catalogue of the Library they are numbered 88, 93 and 107.

MS. No. 88. The Books of Vitruvius form one of many subjects in this volume, which is a small folio, written in single columns on each page on vellum, 104 of the folios being devoted to Vitruvius, the rest to other essays. The headings of the books and other divisions are marked with red capital letters, the initial letters at the commencement of the books being larger than those at the heads of the chapters. The whole seems to be written by the same hand; the *i* is always without any mark whatever over it. *Et* in the middle of words is sometimes written with an &, as *symm&riae* and *hab&*, but not always; at the ends of words *ae* and *oe* are written as diphthongs, otherwise as *ae* and *oe*. The other abbreviations are frequent, but only the usual ones are employed. The numbers of the books are written in cyphers at the tops of the pages, the arguments on the mar-

* My learned friend Dr. C. Leemans, Curator of the Museum of Antiquities at Leyden, has furnished me with the information relating to these three Codices.

gins. There is no date attached to this Codex, but it would appear to belong to the xth century.

MS. No. 93. This folio volume consists of about 96 sheets of vellum, 22 only of which are occupied by *excerpta* from Vitruvius, all written by the same hand. There are double columns on each page; the heads of the books and chapters begin with capital letters, colored red and blue; the *i* is without stroke or dot, and the *et* not abbreviated; the diphthong *ae* is always written with an *e;* but *oe* is not abbreviated; other abbreviations are very frequent. The handwriting indicates the xvth century, but there is no date upon the Codex.

MS. No. 107. This Codex contains only the books of Vitruvius, and, according to the Catalogue, is written in a very old character, apparently of the xith century; it is a folio, composed of 110 sheets of vellum, written in single columns on each page, all by the same person. The first letter of each book is a capital one, in ink, without ornamental embellishment; there is no stroke nor dot over the *i; et* is abbreviated thus &. The abbreviations are not frequent, and corrections, as it seems by the same hand, are written above the words and on the margins.

These seem to be very valuable manuscripts, particularly the first and third. Frequent reference is made by authors to a volume preserved in this Library said to contain the corrections of the learned Vossius. This is described in the Catalogue of the Library (Catalogus Bibliothecæ Lugduno Batavіæ) in these words:—"Vitruvii de Architecturâ libri x. Lugduni 1552. Liber quintus et sequentes ab Isaaco Vossio collati cum MS. emendationibus etiam adscriptis. In quart. Math. 15." Hence it would appear that a copy of Philander's edition has been revised and corrected by Vossius from the MSS. above described.

Simon Stratico collated his text with several manuscripts, the titles of which he gives on the page preceding the Latin text, as also at p. 113 of vol. i. part i. some particulars respecting them.

A Codex in the Library of St. Mark at Venice, and one belonging to Girard Sagredi, Procurator of the Church of St. Mark. These two have been already noticed.

A MS. belonging to the Canons of St. Salvador at Bologna mentioned by Philander in a note on the words *In diatono verò tonum,* lib. v. c. iv.

One in the Library of the Convent of St. Francis at Cesena, in Romagna, Italy.

One which he calls Codex Estensis, without any further remark.

The one at Eton, and one belonging to Lord Oxford.

Four at Florence, severally numbered 10, 11, 12, and 13, the first and third of which appear to have been written about 1300; the second abounds with errors, and consequently does not merit confidence; the last seems to date about 1400.

Three at Milan are also alluded to, with these dates 1462-1474-1500, consequently not very old. The first was written by Bonninus Mambritius; the second belonged to Johannes Vincentius Pinellius; and the third to Frederic Cardinal Borromeo.

Three in the King's and Colbert Library at Paris, under the Nos. 4157, 5438, 5439, and as all coinciding almost to a letter in the disputed passages. The numbers here given, however, do not agree with the Codices in that library, which we have already particularized, p. 122.

Two at Rome are alluded to: one of which formerly belonged to the famous Queen of Sweden, now in the Alexandrine Vatican Library, numbered 1504; supposed to have been written about the viiith century, certainly not after the ixth. The other Vatican Codex is numbered 2229, on vellum, and hardly more recent than the preceding.

F. A. Ebert, in his work on manuscripts, (zur handschrifskunde) vol. 2, Leipsig, 1827, notices the two Codices preserved at Wolfenbüttel, in Lower Saxony, marked 931 and 932. They are both on vellum; the one a small folio of the xith century, (Gud. 69) the other in quarto, supposed to be of the xth century, (Gud. 132). Schneider, who frequently relies on one of these, (Codex Guelferbytanus), does not state which of the two he has adopted for his authority.

And. Schotti, in his Observationum Humanarum, lib. v. Hanoviæ 1615, mentions, p. 233, a manuscript at Toledo, to which he refers when suggesting some corrections in the text of Vitruvius.

Peter Wesseling, in his Observationum Variorum, libri duo, Amstelaedami, 1727, frequently corrects the text of our author from a Codex at Franeker in Holland.

Schneider also mentions, as a valuable manuscript, Codex Wratislaviensis (in Silesia?) membranaceus quem Bibliothecæ Rhedigerianæ inseruit beneficium Johannis Gottlieb Uberi Consiliarii regii.

T. L. D.

District Lunatic Asylums established in Ireland under the Commissioners for general Control,

COMMUNICATED BY W. MURRAY, ESQ. ARCHITECT.

Read at the Ordinary Meeting held Monday, December, 1835.

72, Lower Gardiner Street, Dublin.
October 28th, 1835.

Sir,

I have great pleasure in forwarding to the Institute the following particulars, which I promised you, of the District Lunatic Asylums lately established in this country.

Name of the District Asylum	Year opened	No. of Patients intended for	Land Purchased (ENGLISH) A.	R.	P.	Price per Acre (ENGLISH) £.	s.	d.	Amount of Purchase Money £.	s.	d.	Amount of Building. £.	s.	d.	Furniture, Bedding, & other Contingencies £.	s.	d.	TOTAL. £.	s.	d.
Armagh . . .	1825	104	8	0	23	81	3	11	1,090	5	7	18,094	4	8½	1,715	14	2	20,900	4	5½
Limerick . .	1827	150	11	3	12	259	6	9	3,840	2	10¼	24,120	0	6	1,896	8	1	29,856	11	5¼
Belfast. . . .	1829	104	21	1	11	77	1	11	2,070	0	0	21,838	7	4	1,411	5	8	25,319	13	0
Derry	1829	104	12	5	2	76	4	9	752	18	5	23,507	9	10	1,417	14	1	25,678	2	4
Carlow. . . .	1831	104	15	0	39	152	2	6	2,289	0	3	18,474	5	9	1,789	4	4	22,552	10	4
Maryborough	1833	104	22	2	17	50	8	4	1,140	8	0	21,518	13	6	1,513	1	0	24,172	2	6
Connaught .	1833	150	22	2	28	69	16	2½	1,582	19	5	23,581	9	10	1,965	15	3	27,130	4	6
Waterford . .	1835	100	14	2	12	85	15	0	1,262	14	10	14,313	1	10	1,311	15	11	16,887	12	7
Clonmel . . .	1835	60	11	1	14	119	15	9	1,347	16	9	14,019	6	1	1,220	16	5	16,587	19	3
Total number . . .		980	Patients.									Total Expenditure						£209,085	0	4½

The Board, having completed the erection of Lunatic Asylums for the whole of Ireland, was, at its own request, dissolved in March 1835. Additional ground, however, is about being purchased, and additional buildings have been and are erecting in Limerick and Belfast, contiguous to these asylums, for the sole accommodation of incurable lunatics.

The buildings, in general, are so situated as to become a marked object, and to form a feature of each town; nor has it been found by those, which are longest in operation, that their contiguity to the towns has had the slightest prejudicial effect upon the inmates, as they are as much secluded in their apartments and grounds as if they were more remote.

In Armagh the ground was cheap and the building reasonable; there we built with white limestone, which is abundantly supplied in this country.

In Limerick the land was dear, but the building cheap; the neighbour-

hood abounds with blue limestone, which can be obtained of every size, and at very reasonable prices.

In Belfast both the land and building were dear. We were obliged to build chiefly with brick; the front and cupola are faced with Scotch stone, procured for the purpose from that country.

In Londonderry the land was cheap and building expensive, being principally built of brick, which was procured about fifteen miles from the town.

In Carlow the land and buildings were both expensive; these we built with very fine white granite, with which the neighbourhood abounds.

In Maryborough (Queen's County) the land was reasonable, but the buildings expensive. There we used very beautiful grey limestone; the quarries are about eight miles from the building. The bricks made here failed, in consequence of being impregnated with lime wash; they burst with the weather.

In Ballinasloe (County Galway) the land and building were reasonable. The limestone was supplied in great abundance from quarries about three miles from the building.

In Waterford both the land and building were reasonable. The limestone, which is of a dark blue color, was procured from the County Kilkenny side of the river, about five miles distant.

In Clonmel (County Tipperary) the land and buildings were reasonable. The limestone with which we built is a light grey, and was procured about six miles from the building.

The mode in which Government has established these institutions was, by advancing the money, in the first instance, both for the purchase of the ground and erecting the buildings, which is now being paid back by the counties attached to each, by instalments, at the easy rate of four per cent. principal, without interest. And, in order to keep them free from all private interference, Government still continues to advance money for their support. The Judges, on going circuit, are instructed to pass presentments for the repayment of those loans.

I think I have, in the foregoing statement, touched on every thing that may be considered interesting, or that is in any way connected with those institutions. But, should the Institute deem the subject worthy of any further enquiry, I will be most happy to give all the information I am in possession of, or can obtain for your Institute. My only apprehension is, that I may have intruded myself without affording information.

I have the honor to be, your obedient humble servant,

WILLIAM MURRAY.

T. L. Donaldson, Esq. Hon^{y}. Sec^{y}.

of the Institute of British Architects.

Monsieur et très honoré confrère
Votre très humble et très obéissant
Charles Percier
Paris

Votre Serviteur & Ami très fidèle
Schinkel.
Berlin 126 Juin 1835.

Votre très humble Serviteur
Frederic Gaertner
Munic

Veuillez agréer, Monsieur, avec mes remercîments,
l'assurance de mon entier dévouement
H. de Baz
architecte, membre de l'Institut

Debret, architecte, membre
de l'Institut Royale de France,
Honoraire et Correspondant de l'Institut
des Architectes Britanniques et membre
de la Société Hypothétique de Paris &c.

Votre tout dévoué Ami
et confrère,
Guyot.
Rue St. André des-Arcs, N° 59.

Votre véritable ami et dévoué
confrère Guenepin
Paris

Votre tout Devoué ami
Paris Glandot.

Hittorff
40. Rue Coquenard.

Dr. George Moller.
Directeur des batemens de
S. A. Royale le Grand Duc
de Hesse Darmstadt.

Votre très dévoué serviteur & ami
Chev. Stefano Gasse.
Naples

Brunswick

Votre tres humble serviteur

C. G. Otto.

Directeur des travaux publiques
et orch de la cour.

Munich

Votre serviteur devoué ami

L. de Klenze

Conseiller intime, directeur
g.l et Intendant des batimens
de la Couronne.

Copenhague

Monsieur

votre devoué serviteur

Hansen

La Haye

Votre respectueux Serviteur
et ami tres fidele

Leijenhorst

Hamburg

I am, with much esteem
and consideration
my dear Sir
very faithfully your's,

C. Hasemann

mi dico vostro sincero
amico

Ferdinando Albertolli

Milano li 23 aprile 1831

Monsieur et Cher Collegue

Votre serviteur et fidele ami

Bayer

Bayreuth

Venezia

Divg.mo Obblig.mo Servore

Giuseppe Bozzato

e

Pasquale Rocchetti

Yours

most obedient humblest Servt

Beuth

Counsellor of State

Berlin

New York Sept.r 17.th 1836

with much respect, dear Sir
your faithful & devoted

Alfred Town

Day & Haghe Lith.rs to the King

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